15E44

BAUDOT
MULTIPLEX PRINTING TELEGRAPHS.

DOUBLE INSTALLATION.

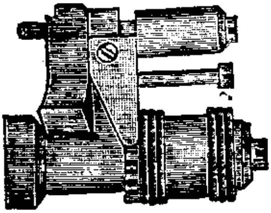
A Complete treatise on the mechanical and electrical working of the system.

BY

GEO: W. HODGE,

AND

W. A. V. D'ROZARIO.



Published with the kind permission of

SIR SYDNEY HUTCHINSON, KT., M.INST. C.E., M.I.E.E.,

Director General of Telegraphs

CONTENTS.

CHAPTER I.

Construction of the Alphabets and Codes. The Baudot Code ideal for type-printing telegraphs. The primary theory of the Baudot System.

CHAPTER II.

The Baudot transmitter. Keyboard. Construction of keys. Key-locking device. Cadence telephone, its necessity and construction. Maintenance. Faults and remedies.

CHAPTER III.

The Baudot Relay, its description and action. Adjustments of the relay. Working adjustments.

CHAPTER IV.

Driving gear. Pedal lift. Automatic lift. Maintenance of the driving gear.

CHAPTER V.

The Baudot Receiver. Construction and action of parts. Electrical and mechanical adjustments. Faults and remedies. Adjustment for progression of paper tape and for impression.

CHAPTER VI.

Distributor plates, their description and use. Brush-Arms. Adjustments. Faults and remedies.

CHAPTER VII.

Synchronism. The Governor. Synchronism between stations. The Electro-corrector. The Moderator. Local synchronism between Distributor and Receiver. Brake Magnets. Maintenance, Faults and remedies.

CHAPTER VIII.

Terminal working. Batteries. Adjustments. Opening Communication. General remarks.

CHAPTER IX.

Translation. Theory and practice. Switches. Distributor plates. Opening communication with Terminals. Adjustments and faults.

CHAPTER X.

13E4

BAUDOT
MULTIPLEX PRINTING TELEGRAPHS.

DOUBLE INSTALLATION.

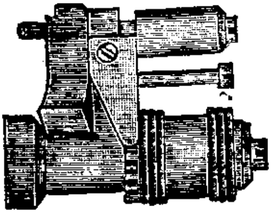
A Complete treatise on the mechanical and electrical working of the system.

BY

GEO: W. HODGE,

AND

W. A. V. D'ROZARIO.



Published with the kind permission of

SIR SYDNEY HUTCHINSON, KT., M.ʳ INST. C.E., M.I.E.E.,

Director General of Telegraphs

PREFACE.

The record achievements of the Baudot system in India, and the probable installation of the same in all the important offices in India, has induced the authors to publish this treatise in the hope that it will be helpful to all engaged in the maintenance and working of the system.

To thoroughly master the working of a complicated multiplex system like the Baudot, it is necessary, not only to know the general principles on which it is based, but also to understand the construction and function of every part of the mechanism in detail. Care has therefore been taken, in chapters II to VII, to describe in detail the construction of the instruments and the principles on which they are worked.

To those not actually engaged in the operation and maintenance of the system these details will necessarily be tedious, and the reader is therefore advised, in the first perusal, to gather a general idea of the system, before attempting to follow the details which are important only to those engaged in working the system.

The authors most gratefully thank the Director General of Telegraphs for the kind permission accorded to the publication of this treatise. Thanks are also due to Mr. C. T. Williams, the Officer in charge of the system in India for kind assistance, to Messrs J. Tyrrell, E. Barrett and E. Dykes of the Central Telegraph Office, London, for valuable information during the experimental installation of the system, and to Messrs. G. Wren, R. Osborne and A. B. Smith, of the Indian Telegraph Department for practical notes and information most willingly given.

GEO: W. HODGE.
BAUDOT TELEGRAPH
MASTER.

W. A. V. D'ROZARIO.
AUTO-TELEGRAPH
MASTER.

CONTENTS.

CHAPTER I.

Construction of the Alphabets and Codes. The Baudot Code ideal for type-printing telegraphs. The primary theory of the Baudot System.

CHAPTER II.

The Baudot transmitter. Keyboard. Construction of keys. Key-locking device. Cadence telephone, its necessity and construction. Maintenance. Faults and remedies.

CHAPTER III.

The Baudot Relay, its description and action. Adjustments of the relay. Working adjustments.

CHAPTER IV.

Driving gear. Pedal lift. Automatic lift. Maintenance of the driving gear.

CHAPTER V.

The Baudot Receiver. Construction and action of parts. Electrical and mechanical adjustments. Faults and remedies. Adjustment for progression of paper tape and for impression.

CHAPTER VI.

Distributor plates, their description and use. Brush-Arms. Adjustments. Faults and remedies.

CHAPTER VII.

Synchronism. The Governor. Synchronism between stations. The Electro-corrector. The Moderator. Local synchronism between Distributor and Receiver. Brake Magnets. Maintenance, Faults and remedies.

CHAPTER VIII.

Terminal working. Batteries. Adjustments. Opening Communication. General remarks.

CHAPTER IX.

Translation. Theory and practice. Switches. Distributor plates. Opening communication with Terminals. Adjustments and faults.

CHAPTER X.

ERRATA.

Page.	2,	line	47,	for	*combinations*	read	*combination*
,,	5,	,,	45	for	*eleotro-mgnets*	read	*electro magnets*
,,	12,	,,	4,	for	*to be resistance*	read	*to a resistance*
,,	16,	,,	8,	for	*these to*	read	*to these*
,,	21,	,,	36,	for	*of axle*	read	*of the axle*
,,	24,	,,	40,	for	*consist*	read	*consists*
,,	31,	,,	4 ,	for	S^6 *and* S^4	read	S^6 *and* S^7
,,	32,	,,	7,	for	*stud* S	read	*stud* S^6
,,	33,	,,	22,	for	*clicks* R *and* R	read	*clicks* R *and* R^1
,,	33,	,,	23,	for	W^2 *and* W	read	W^2 *and* W^3
,,	33,	,,	31,	for	*wheel* W	read	*wheel* W^1
,,	33,	,,	41,	for	*kink*	read	*link.*
,,	75,	,,	36,	for	*it will, be*	read	*it, will be*
,,	81,	,,	33,	for	*ring I, the*	read	*ring I. The*
,,	86,	,,	8,	read	*7 and 8 of ring III.*		
,,	86,	,,	25,	for	*first*	read	*firsts*
,,	102,	,,	12,	for	*principle*	read	*principal*
,,	102,	,,	23,	for	*ased*	read	*used*
,,	109,	,,	21,	delete	*and* after 30		
,,	110,	,,	31,	for	*station .*	read	*station,*
,,	111,	,,	11,	for	*segments*	read	*segment*
,,	111,	,,	28,	for	*positions*	read	*position*
,,	112,	,,	19,	for	*is a leak*	read	*are a leak*
,,	118,	,,	17,	for	*axes*	read	*axis*
,,	119,	,,	20,	for	*arm segments*	read	*arm, segments*

CHAPTER I.

PRELIMINARY.

1. The many systems of telegraphy used in India, *viz.*, Simplex (closed and open circuit), Duplex, Quadruplex, and Wheatstone's Automatic, have each their own particular advantages, and serve useful purposes in their respective spheres. With the exception of the last named, these systems, as in general use, belong to a class which may be termed non-registering, because they are accoustic and leave no record of the signal. The Wheatstone's Automatic registers signals on tape, but they are symbolic, *i.e.*, they are recorded in Morse characters which require to be translated into Roman characters before they can be made intelligible to the public. A system which records characters that require translation cannot, especially for the uninitiated, be rightly termed a printing system, and the latter name should, therefore, be applied more correctly to those systems which register signals in Roman characters, *e.g.*, the Stelje, the Hughes, the Murray, the Baudot, etc. Hence we may confine the term printing telegraphs to those systems, in which the record appeals to the mind through the eye in characters not requiring the training of the telegraph operator, *i.e.*, in characters Roman rather than symbolic.

2. In selecting a system for purposes of commerce, the most desirable is one which entails the least number of operations from the moment that a telegram is handed in for transmission to the moment that it is ready for delivery at the distant end. In this sense, duplex and all other manual systems stand unrivalled, inasmuch as the simple manipulation of a key at one end and the recording in manuscript at the other, is all that is required. When, however, it is desired to go beyond the speed at which an operator can signal or write accurately, manual systems must give place to mechanical ones, and among these the best will be those which come next in order of simplicity to manual working.

3. The Wheatstone's Automatic, although a very rapid working system, has drawbacks in the sense that two distinct operations, *viz.* *punching* and *transcription* have to be performed by hand, apart from *transmitting* and *receiving*, which are effected automatically. It follows, therefore, that although traffic may be rushed through a wire at a high rate, a considerable amount of time is lost both in preparing the tape for transmission at the sending end, and in transliterating the symbols on the tape at the receiving end, into readable matter. The Wheatstone's Automatic is, therefore, not so well adapted for the immediate and complete disposal of traffic as the

punching and transcribing and reproduces the message in Roman characters. The drawback of the Baudot system, however, is that the tape has to be gummed to a form, and skeleton copies of all *received* telegrams have to be prepared.

4. The construction of the instruments of different systems depends a great deal on the kind of *code* used. Most telegraph signals consist of variations either in the duration or in the direction of electric impulses, and sometimes both in duration and direction. Signals also may consist of variations in strength besides those of duration and direction, as in quadruplex; but these variations in strength have the disadvantage of augmenting the inductive effects in neighbouring wires and are consequently detrimental to speed on those wires.

5. In the Morse system, letters, the frequency of which is greatest, *i. e.*, those which occur oftenest in the language, are formed with the least number of units. Taking the dot as an unit of time, a bar as three units, the space between symbols constituting a letter as an unit, and the space between two letters of the some word as three units, in the letters E, I, T, A, N and S, there are, respectively 4, 6, 6, 8, 8 and 8 units of time,; similarly in the figure 0 there are 22 units. It may be seen therefore that the Morse Code consists of letters ranging in duration from 4 to 22 units of time, the average being about 8 units per letter. It is therefore not an equal letter code.

6. The Hughes Code, which is a very simple one, consists o positive impulses transmitted at different periods of time, the intervals between these impulses being no current or zero intervals. The number of units per letter, which varies from 1 in the letter A tc 28 in the figure space, is dependent on the point at which, in a giver cycle, a contact slide rotating over a circular disc is brought ir connection with a pin, which latter is worked by a lever connectec to the particular key that is depressed. The attendent result i that a strip of paper is simultaneously pressed against the types or corresponding parts of wheels rotating synchronously. The average number of units per letter for the Hughes Code works out to abou 14.

7. It may be seen from the above that a considerable amoun of time is lost by using codes which necessitate a large number o units per letter, and that a larger number of words could be transmitted through a wire if the same letters are signalled by the us of a smaller number of units. It is very essential besides, for th simplification of mechanical appliances that all the letters used, irrespective of their frequency, should be made up of the same number o units, in other words the code used must be an equal letter code The Baudot Alphabet which is constructed on the above principl consists of five units per letter. Each letter is made up of five impulses which may be either all positive or a combinations of both positive and negative impulses. There are no spaces between the fiv

impulses, and it therefore happens that when any two or more impulses succeeding each other are of the same direction as in the case of the letters É, O, N, P, they produce the same effect as a single impulse of 2, 3, 4 and 5 units duration, respectively, in that direction.

8. The Baudot Code is shewn in fig. 1, in which it will be seen that there are 30 permutations of the five impulses, positive or negative, admitting of 30 signals. By means of a mechanical device it has been made possible to so alter the position of the receiver type-wheel relative to a fixed plate, both of which are fixed on the same rotating spindle, as to make these 30 signals answer for a total of 60 letters, figures and signs. The permutations shewn in columns 3 to 7, (fig 1) answer for either a letter, a figure, or a sign as shown in columns 1 and 2, according to the above-mentioned change in the position of the type-wheel. This change is controlled by the two last permutations marked 'letter' and 'figure' in columns 1 and 2 respectively.

It will be seen from fig. 1, that the first seven letters A, E, É, I, O, U, Y are formed by permutations of the 1st three keys only. The next seven B, C, D, F, G, H, J are formed by adding the fourth key to the first seven permutations in reverse order. The third group of seven letters K, L, M, N, P, Q, R consists of the addition of the 4th and 5th keys to the first lot of seven, and the last set of seven is formed by adding the 5th key only to the first group of seven, once again, in reverse order.

9. Given the Baudot Alphabet it is next necessary to consider how the variations of these five impulses may be employed so as to produce readable matter at the distant end of a wire. As each signal consists of five emissions of current, the employment of five keys will enable these emissions to be varied to suit the Baudot Alphabet. As these impulses are emitted at different points, as many wires as there are current emissions would be required. But for economic reasons and from a commercial point of view, this emission of current at five different points must be imparted to a *single* wire at five intervals of time quickly succeeding each other. This can be effected by connecting the line to the five keys consecutively by means of a revolving contact arm or trailer A, at station S, (fig. 2) which is joined permanently to the line wire. At the receiving station a similar arm A' is placed in connection with five electromagnets consecutively. Thus the five keys at the sending station can be placed in connection with five electromagnets at the receiving station by means of two revolving trailers. If now both these trailers A and A' are kept rotating by means of suitable clockwork, at the *same speed*, and are started from similar points P and P' on their respective dials, they will be moving over corresponding points at any given time. Impulses positive or negative transmitted by the keys K^1, K^2, K^3, K^4, K^5, at station S, will therefore be received on the electromagnets E^1, E^2, E^3, E^4, E^5, at station S'. The five electromagnets or any number of them, according to the number and

order of the keys depressed, can thus be operated *one after the other* and be made to actuate suitable mechanical devices so as to imprint the required letter or sign. Further, these mechanical contrivances have to be so arranged as to be brought into play only after the fifth impulse transmitted by key K^5, has arrived at the receiving station.

10. In the arrangement shewn in fig. 2, if it is required to operate the electro-magnet E′ each time key K^1 is depressed, it is necessary to ensure that the trailer A′ at station S′ passes over the point P′ at the same time that the trailer A passes over the point P at station S. It is, however, practically impossible to keep two machines going at the same speed, and what is more difficult, to keep the two trailers in phase, *i. e.*, to make the rotating trailers A and A′ simultaneously pass over identical points on their respective dials for any length of time. The arm A will therefore, either gain or lose on A′ and though both be started together they will ere long be passing over different sections of their respective dials; in other words, they will be out of phase even though their rates of revolution are *almost* identical. To prevent this, one of the arms, say A′, must be run a little faster than the other, and means adopted to check its motion once in two or three revolutions. This could be effected by sending a current from any point P^6 on the dial at station S, once in each revolution of the trailer A, through the line and trailer A′, to a similar point P^6 at station S′ and through it to a sixth electro-magnet E^6. The armature of E^6, when worked can be made to put a very momentary checking or correcting action on the rotation of A^1 which can thus be prevented from gaining on A, and consequently kept in phase. When the two levers are maintaining identical speed and phase, they are said to be synchronous. As, however, the currents emitted at one station do not simultaneously reach the distant station on account of retardation, the synchronism obtained is only approximate, but by the means adopted above this approximation is made as close as possible.

11. An appliance similar to that depicted in fig. 2 may be termed a distributor, as it enables the line to be as it were distributed between five or more points successively. In practice, the trailer arms A and A′ give place to continuous rings of metal, and the points to which the keys and electro-magnets are connected consist of small insulated segments, of a metallic ring (fig. 3.) The continuous ring is joined permanently to the line and the segments of the divided ring are joined to different parts of the transmitting and receiving apparatus. A pair of rotating metallic brushes (fig. 3.) connect the two rings together, and the different segments of the divided ring are thus placed consecutively in connection with the continuous ring and through it to the line. The several kinds of distributors in the Baudot system vary according to the kind of work they are designed to do, but only those used in double terminal and translation working will be described in this treatise.

12. In fig. 3., segments 1 to 5 of the divided ring at station S are joined to five keys K^1, K^2, K^3, K^4, and K^5, segment 6 to earth, segments 7 to 11 to five electro-magents E^1, E^2, E^3, E^4 and E^5, segment 12 to earth through a relay, segment 13 to the positive main battery and segment 14 to the negative main battery. These are the usual connections at what is termed the *correcting station*, *i. e.*, the station which sends the correcting currents to check the speed of the brushes at the distant or corrected station. At the corrected end, the usual connections are as shewn at station S^1, *viz.*, the first five segments are joined to the five electro-magnets, the next five to the five keys, and the last four segments to a relay which works the electro-corrector or sixth electro-magnet. It will be seen from the above, that the line at the *correcting* end is placed first in connection with the keys which constitute the *sending arm*, at the same time, that it is joined at the *corrected* end to the electro-mgnets which constitute the *receiving arm*. Immediately after this, the *sending arm* at the *corrected* end is joined to line, while the brushes at the *correcting* end are passing over the *receiving arm*. The line then is earthed through a relay at the correcting end, after which positive and negative impulses are transmitted from the *correcting* and are received at the *corrected* end on the last four segments which are joined together. The object of these connections will be explained in Chapter VIII, but it may be noted here that in any one revolution of the brushes at each station, five unit impulses of varying direction and sequence can be sent and received, not *simultaneously* but *alternately* by both stations, thus admitting of a letter being received at each station during *one revolution of the brushes*.

13. In practice each revolution of the brush arms lasts about a third of a second, and the impulses from either station have during this period to be transmitted in proper time and turn. It is evident that, if any key is depressed after the brushes have passed the segment connected to it, the impulse will be lost. Means must therefore be employed to keep the operators at each end duly informed of the exact time at which they have to transmit. This is done by means of a telephone through which a current is sent once in each revolution, just before the brushes arrive on the sending segments. The click in the telephone warns the sending operator to depress the keys. This beating of the time is termed the *cadence*.

14. If two stations are connected together by a short line it would be possible to transmit fairly strong currents which could actuate direct working electro-magnets. But since in practice the lines are generally long, relays are used. The principle of pairs of revolving brushes over divided and undivided rings being applied to place the several eleotro-mgnets, each in turn, in connection with a battery in the local circuit of the relay which latter is joined to line. A distributor may therefore be made up of many rings whole and divided, each of which has its own particular function. With the electro-magnets

the relay, the object of joining segment 11 at both stations to the relay is evidently to provide against retardation effects. It must be here remarked that the keys on the sending arm are while in the rest position, permanently joined to the negative main battery. When, therefore, less than five keys are depressed, the keys at rest always send a negative current to the line and obviate the ill-effects of induction which would otherwise affect the signals by permitting currents, induced or natural, to assert themselves as disturbing elements.

15. The principal instruments and mechanism in a Baudot double terminal set, which will be described in the succeeding chapters, are as follows:—

(*a*). The key-board or transmitter consisting of five keys pivotted on a common axle with suitable electrical connections.

(*b*). The relay which works several electro-magnets in turn in a local circuit.

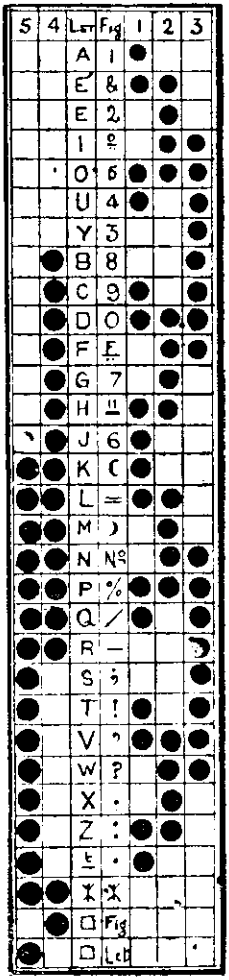
(*c*). Suitable clockwork to convey the necessary force, imparted by a weight or motor for the rotation of the Receiver type-wheel and Distributor brushes.

(*d*). The Receiver consisting of five electro-magnets worked in the local circuit of the relay, the armatures of which operating a train of suitable mechanism, release a printing arm at various positions around the type-wheel, corresponding to the signal.

(*e*). The distributor plates consisting of concentric metallic rings, whole and divided, fitted on an ebonite bed and insulated from one another, over which pairs of metallic brushes, carried on revolving arms, are rotating and placing any two rings in connection with each other.

(*f*). The means adopted for the maintenance of the synchornous movement of the revolving parts.

DIAGRAM—Chapter I.



5	4	Let	Fig	1	2	3
		A	1	●		
		É	&	●	●	
		E	2		●	
		I	º		●	●
		O	5	●	●	●
		U	4	●		●
		Y	3			●
	●	B	8			●
	●	C	9	●		●
	●	D	0	●	●	●
	●	F	£		●	●
	●	G	7		●	
	●	H	″	●	●	
	●	J	6	●		
●	●	K	(	●		
●	●	L	=	●	●	
●	●	M	)		●	
●	●	N	№		●	●
●	●	P	%	●	●	●
●	●	Q	/	●		●
●	●	R	—			●
●		S	;			●
●		T	!	●		●
●		V	'	●	●	●
●		W	?		●	●
●		X	.		●	
●		Z	:	●	●	
●		t̲	·	●		
●	●	X	X			
	●	□	Fig			
●		□	Let			

Fig. 1.

DIAGRAM—CHAPTER I—(*concld*).

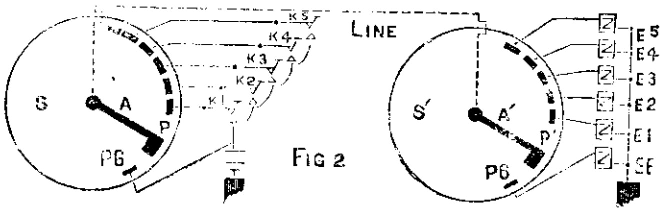


FIG 2

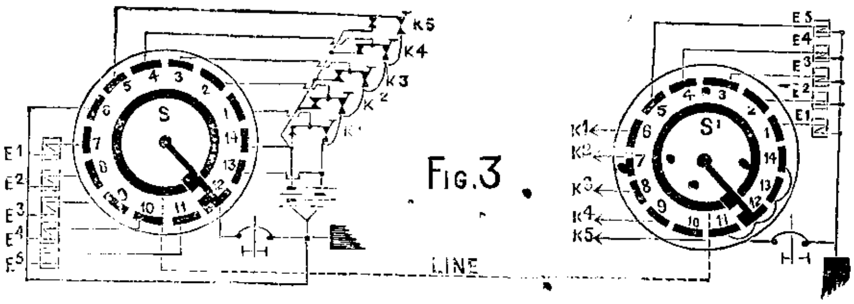


FIG.3

CHAPTER II.

TRANSMITTER.

16. The transmitter consists of a key-board containing five keys K^1, K^2, K^3, K^4, and K^5, (fig. 4) resembling those of a piano. These keys are placed on either side of a central block or dummy key of black wood B, two on the left and three on the right. A switch lever, pivotted at a point P (figs 4 and 7) and free to move in a horizontal plane, is fixed on the dummy key. When this switch lever is turned to the right or left by means of an ivory knob K (fig. 7) it places the line in connection, either with the negative main battery, or with the relay, through the distributor segments and the transmitter keys at rest.

17. The keys are made of wood; fig. 6 gives a sectional view of one of them. R is a rectangular block of metal fitted to the base by means of two screws, one of which is shewn in the figure. The block is provided with a semi-circular groove which exactly fits over the steel axle A (figs. 5 and 6). This axle runs across the whole length of the base of the transmitter, and the keys are balanced on it so as to move in a vertical plane. The keys can be easily lifted off the axle, on which they simply rest. The axle A is so constructed that it is provided with round washers W (fig. 5), which are cast with it. These washers come between the keys and help to keep them from working laterally, and thus affecting each others action. The broad washer near the middle of the axle is exactly opposite to the dummy key and serves to keep keys 1 and 4 apart.

18. The three keys K^1, K^2, K^3, to the right of the dummy, are worked by the first, second and third fingers of the right hand; and the two keys K^4 and K^5, to the left of the dummy, are worked by the first and second fingers of the left hand. The upper surfaces of the keys are lined with ivory for about five-eighths of their length.

19 At the upper end of each key is inset a piece of brass B (fig. 6) to which is attached one end of a spiral spring S; the other end of the spring is terminated in a small loop, which is connected by a screw to a small stud of brass B^1 (fig. 5 and 6); which in turn is connected by means of a metal strap M (fig. 5) to a screw B^2. From B^2 a connecting wire is led to one of the segments of the distributor. The spiral spring S in addition to forming part of the electrical circuit between the

20. To the brass piece B (fig. 6) is also rigidly fitted a flat steel spring F, which is faced on the top with a small strip of german silver, bent over it from one side to the other for about ¼th of an inch, and forming, as it were, a cap over the spring. The spring F, under the action of the keys, works between two broad L-shaped plates L and L^1 which limit its play and which serve also as a cover for the key-board fittings. The plates L and L^1 are kept in position by means of four clamping screws, only two of which C and C^1 are shewn in fig. 6. On the upright sides of each of these plates are fitted five german silver studs or contact points, two of which P and P^1 are shewn in fig. 6. When the plates are fixed in position these points come exactly opposite the two sides of the german silver caps on the top of the flexible contact springs F. The clamping screws C and C^1 (fig. 6) work into the sockets c and c^1 (fig. 5), which are embedded in the wooden frame, and through them the plates L and L^1 are connected as shewn by the dotted lines (fig. 5). When the keys are at rest the contact springs F make contact with the studs P, opposite to each of them, fitted to the back plate L; but when the keys are depressed the springs are brought into contact with the studs P^1 on the front plate L^1.

21. Under keys K^4 and K^5 (fig. 4) are fitted two electro-magnets E and E^1 the coil of each of which is wound round a soft iron core I (fig. 6) which by contact with the South pole of the square U-shaped permanent magnet becomes a prolongation of the South pole. The core outside the coil is bent upwards at right angles and comes directly beneath one end of an armature A fitted in a cavity, at the base of the front end of the key. The armature is pivotted on a small horizontal pin P and is free to move vertically like a see-saw. The North pole of the permanent magnet lies beneath the other end of the armature. The object of pivotting the armature is to keep its lower surface always parallel to the poles of the electro-magnet beneath it, no matter what the position of the keys may be, and thus to ensure maximum attraction.

22. When the keys K^4 and K^5 are at rest the force of attraction on the armatures, due to the permanent magnet, is not sufficiently strong to overcome the force of the antagonistic spring S and draw the keys down. When, however, the keys are depressed the armatures are placed in a more powerful field, and are held down, even after the operator has released the pressure of his fingers on the key, till the cadence or release current (para. 13) passing through the coils of the electro-magnets in a direction such as to temporarily demagnetise or weaken the attractive force of the magnets, releases them. When the keys are depressed the lower faces of the armatures so adjust themselves that they come in contact with the poles of the magnet U and have therefore a tendency to stick even after the cadence current has weakened the attractive force of the magnet. To prevent this, the faces of the

armatures adjacent to the magnet are veneered with thin sheets of brass which act as anti-contact surfaces. If this does not obviate sticking one or two thicknesses of tissue paper may be placed between the armatures and the magnets.

23. The object of the electro or locking magnets is to keep the fourth and fifth keys held down for a fraction of a second longer than the first, second, and third keys; because there is roughly, a time interval of from an eighth to a tenth of a second between the hearing of the click in the telephone and the arrival of the brush on the segments connected to the fourth and fifth keys.

It may be here mentioned that ring *2* of the distributor in a double terminal set is made up of fourteen segments of equal size. The segments by which the outgoing currents are sent are five in number and occupy five-fourteenths of the circumference of the ring. As will be seen later each revolution of the brushes lasts one-third of a second; it follows therefore that the time during which the brushes transit the five segments on the sending arm is $\frac{5}{14}$ths of $\frac{1}{3}$rd of a second, *i.e.*, $\frac{5}{42}$nds of a second and the time that the brushes transit one segment will be one-fifth of this or $\frac{1}{42}$nd of a second. It is evident from this that the time interval which lapses between the hearing of the click on the telephone and the arrival of the brushes on segments 1, 2, 3, 4, and 5 which are connected to the keys of the keyboard or transmitter will be $\frac{1}{42}$nd, $\frac{2}{42}$nd, $\frac{3}{42}$nd, $\frac{4}{42}$nd, and $\frac{5}{42}$nd of a second, respectively, *i.e.*, keys 5, 4, 3, and 2, will have to be pressed down $\frac{4}{42}$nd, $\frac{3}{42}$nd, $\frac{2}{42}$nd and $\frac{1}{42}$nd of a second longer than key 1. Since in practice it is difficult to judge such fine differences of time and practically impossible to raise the fingers alternately in their correct order, all five keys are depressed simultaneously for *not less* than $\frac{1}{14}$th of a second and all are released simultaneously. On release, keys 1, *2* and 3 immediately fall back to their position of rest, but the locking magnets hold down keys 4 and 5 for about a fourth of a second longer, after which the cadence current releases them and the cycle of operation can once again be repeated. The object of the locking magnets, apparently from the above, is to ensure the depression of keys 4 and 5 until the brushes have passed over the segments connected to them.

24. **Cadence.**—E is an ebonite plug (fig. 8a) fitted to the end of a metal tube T and provided with a brass socket S into which a screw S^1 fits. A hole is drilled through the ebonite plug and the bared end of an insulated flexible copper wire is led through and secured to the screw S^1. Another tube T^1, (fig. 8) of smaller girth is fitted at right angles into the tube T and the free end of the flexible wire is passed through both these tubes and connected to one of the terminals of a telephone. One end of a bar magnet B is so shaped and fitted into the tube T^1 that it admits of the flexible wire passing between it and the tube without any difficulty

to its length, passes through a socket plate P fitted to the telephone. The soft iron core C of the telephone is magnetised by contact with the North pole N of the bar magnet. One end of the coil, which is wound to be resistance of 30 ohms, is connected to the screw S^2 and the other end by means of a screw S^3 to a brass plate P^1, which is connected by body screws to the socket plate P and through it to the magnet and tubes T^1 and T. The lower end of the tube T fits into the socket D (figs. 4a and 5) which is connected to earth, by means of the screw G (fig. 5) and terminal screw 7. The screw S^1 (fig. 8a) forms connection with the spiral spring G^1 which is attached to the plate P^1 (fig. 4a) and through it to one end of the coils of the locking magnets; the other end of these coils is joined to terminal screw 6. The two coils of the locking magnets and the telephone are thus joined in series between terminal screws 6 and 7 (fig 5), and the cadence current which works the telephone is therefore common to them.

25. The tube T^1 can be moved, in a horizontal plane, in the tube T to a position convenient to the operator.

As both hands of the operator are engaged in working the keys it is necessary to have some appliance on which to place the messages whilst they are being transmitted. For this purpose a wooden desk R (fig. 4) is attached to a horizontal arm A which fits on to the tube T (figs. 4 and 8). The arm A can be tightened or loosened by clamping screws S, S^1 (fig. 4) and can be moved in a horizontal plane; the slope of the desk can also be regulated at C (fig. 4). A rectangular wire frame, fitted loosely on two supports attached to the desk, is placed on the messages to keep them from being blown away.

26. The switch referred to in para. 16, is placed between the two sets of keys. It consists of a brass lever L (fig. 7) pivotted on a shoulder screw P and free to move between the studs S^3 and S^4 which are connected, respectively, to the negative line battery and relay. The pressure of the lever against the studs is regulated by means of a springy concavo-convex steel washer W (fig. 7) which is placed between a brass washer B and the lever; the concave portion of W faces downwards. The lever is worked by means of an ivory knob K fitted to one end of it, and between this knob and the pivot screw P is fitted a two-pronged switch S^5 consisting of a sheet of brass bent around the lever so that the prongs P, P^1 (fig. 7a) come under the lever and rub against two sets of studs S, S, and S^1, S^1, fitted to the wooden base on either side of the lever. The pronged switch is insulated from the lever by means of a square ebonite washer E (figs. 7 and 7a) on which it rests. The screw S^2 securing S^5 to the lever is bushed with ebonite. This pronged switch S^5 places either the studs S S, or S^1, S^1, in connection with each other according as the switch lever L is placed to "Send" or "Receive," *i.e.*, according as the lever

and S^1 S^1 are not used in double working and their object will not, therefore, be referred to in this treatise.

27. The wires leading from the key board to the distributor and other instruments in the system are led through a metal tube fitted vertically to the base of the transmitter. This tube which passes through a slit in the table is provided with a worm on its outer circumference over which a large nut works and secures the transmitter to the table. The slit in the table is ten inches long and an inch wide and allows the operator to adjust the position of the key board which can be pushed well back to suit the convenience of the operator on the sending arm, or be put out of his way on the receiving arm.

28. The points of contact should always be kept scrupulously clean. Fine emery paper No. 000, sometimes called blue-backed from the colour of the paper on which the emery is deposited, should be used for cleaning. The best method is to have a flat piece of wood wrapped with emery paper similar to the buff sticks used by watchmakers. To clean the german silver studs or contact points on the plates of L and L^1 (fig. 6) remove the plates and placing them on the edge of the table rub the points with the broad side of the emery stick. This will clean all the points of contact in one operation and ensure a perfectly flat and uniform surface.

To clean the rest contact surfaces of the flat contact springs, remove the back plate L and press down all keys so that the springs rest firmly on the front plate. Carefully clean the contact surfaces with the emery stick, put back the back plate and release the keys. The emery stick should be moved vertically and lateral motion avoided.

To clean the working contact surfaces, remove the front plate L^1 and with the keys in the position of rest clean the contact surfaces and put back the front plate.

Dust between the points of contact should be avoided, and for this reason the space between the plates is shut in by means of strips of insulating material.

29. Neglect of these precautionary measures results in a failure of emission of the working currents by the particular key, on the contacts of which dust or oxide exists. On the other hand, a dirty rest contact produces a complex fault. For example, with a dirty rest contact existing on the third key, an extra third will be produced whenever a second is transmitted. This is easily understood from a consideration of the theory which will be explained later. For the present it must be assumed that the relay is so adjusted that the tongue remains against the stop to which it is put by the last current operating the relay, *i.e.*, the relay is adjusted neutrally. Thus when a positive impulse is sent through the

relay, the tongue remains on the working contact until the following negative impulse sends it back to the rest contact. Considering the case of a dirty *rest* contact on the third key K^3, the effect is tantamount to the negative battery being cut off from that key. It is apparent in this case that when a positive impulse is sent on the second key K^2 only, *i.e.*, when the letter E is signalled, as the relay is adjusted without a bias its tongue will continue to remain against the working stop until the negative current from the fourth key sends it back to the rest stop. The attendant result is equivalent to a depression of the second and the third keys and a consequent prolongation of the effect produced in the relay by the positive impulse from the second key. The letter I will be recorded instead of E in consequence of the extra third being received in the recording receiver.

In the case in point, with a dirty working contact, the depression of the third key, alone or in combination, results in failure of the positive impulse from that key. Apparently when this key is used in combination with the second the fault will not show, because the positive impulse from the second key will send the relay tongue to the working stop where it will remain till the following negative impulse, which obviously will not be from the third key, is received.

Faults of this nature may also be caused by the contact springs F (fig. 6) not making contact with their respective studs either when the keys are at rest or depressed, in which case the negative or positive battery respectively is cut off from the faulty keys. Care should therefore be taken to see that the springs F make firm contact in either position of the keys. The above fault may be due to the contact springs having been bent either forward or backward, resulting in the first case in their not touching the rest stop and in the latter in their pressing with too much force against the rest stop. In the latter case when the key is depressed the extra pressure is removed but the contact spring does not come in contact with the working stop.

30. When a contact spring does not touch the back plate it will be seen that, on the receiving arm, with the switch L (fig. 7) to "Receive" a failure on the particular key will result. It may, however, occur that a failure on the third for instance may be caused by a faulty contact on the fourth key, due to the relative position of the segments of the first ring; this will be more apparent from what will be seen later.

31. A failure of positive impulses on any particular key may also be caused by the spiral spring S (fig. 6) having too much tension and necessitating extra pressure being exerted by the fingers. The fault is most apparent on the third key as it is difficult to exert uniform pressure with the third finger. A locking magnet under the third key will probably obviate this. The tension of the spring S (fig. 6) should be sufficient to cause the keys on being

released, to return to the rest position without producing any vibration of the contact spring F.

A failure of positive or negative impulses on all keys may be due to the clamping screws C and C^1 (fig. 6) not being driven well home, or to the battery being disconnected at the switch board The negative may also be cut off by the switch lever L not making firm contact with the stud S^3 (fig. 7). This may be due to the pivot screw P being loose. The above fault with the switch in the position "receive" will result in a failure of received signals.

32. Care should be taken that the action of the key on the axle A (fig. 5) is free and easy. The axle should be kept clean and free from rust else a sticking of the keys will result. The keys sometimes have a tendency to get off their bearings and give rise to unnecessary friction, due to a faulty spiral spring.

33. Extra impulses from the fourth and fifth keys may be due to the key locking magnets being too strong. The result of this will be observed by a signal, following one in which either the fifth or fourth keys or both have been used, containing an extra fifth or fourth or both respectively; the reason is that the keys are not released by the locking magnets, because the cadence does not sufficiently weaken the field to enable the antagonistic spring S (fig. 6) to draw back the key. To remedy this fault, insert a sheet of tissue paper between the armature and the poles of the locking magnet.

34. Failures on the fourth and fifth keys will be caused by the locking magnets becoming weak. To remedy this remove the magnets and place them across the poles of a small dynamo until they are magnetized sufficiently to carry their own weight. It sometimes happens that the locking magnets being too strong do not release the keys even though tissue paper is inserted between the poles and the armatures. When this happens their magnetism can be reduced by placing them for a short time across the poles of a dynamo so that the lines of force of the field magnet are opposed to those of the locking magnets.

35. The cadence click in the telephone is sometimes weakened by a faulty position of the diaphragm, or a loose screw or connection in some part of the circuit. A probable point is the screw S^2 (fig. 8). One of the causes of a weak click is due to the connecting wires being reversed, when for any purpose the telephone has been taken to pieces; this is, however, of rare occurrence. A more likely fault is a failure of the cadence altogether, which may be due to a short circuit between the screws G and G^1 (fig. 5) or between the flexible wire W (fig. 8) and the tube T and T^1. If with the failure of the cadence, keys four and five also are not held down, the fault is probably due to a disconnection between terminal screws 6 and 7 of the

the cadence battery being cut off or to a loose or faulty connection outside the key-board.

36. The electromotive force of the cadence battery is 20 volts; the current through the cadence circuit is, therefore, about 220 milliamperes, the resistance of the telephone and each of the locking magnet coils being 30 ohms. The connections as they actually are under the base of the key-board are shewn by the dotted lines in fig. 5. Reference these to will be made in the chapter on Terminal working.

DIAGRAM—CHAPTER II.

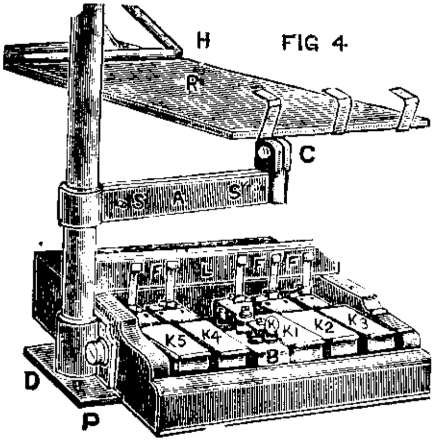
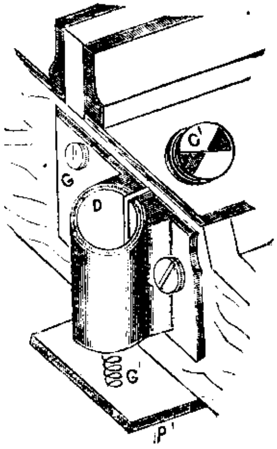


FIG 4


FIC 4 A.

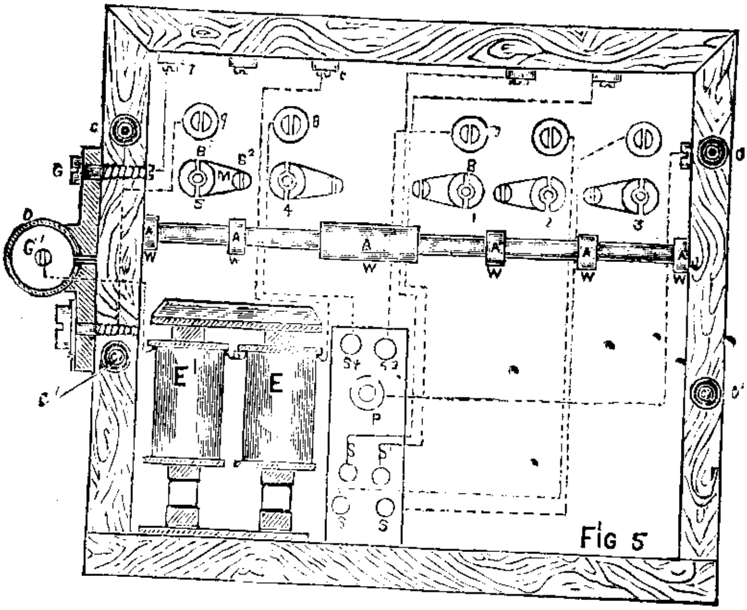


Fig 5

DIAGRAM—CHAPTER II—(*concld*.

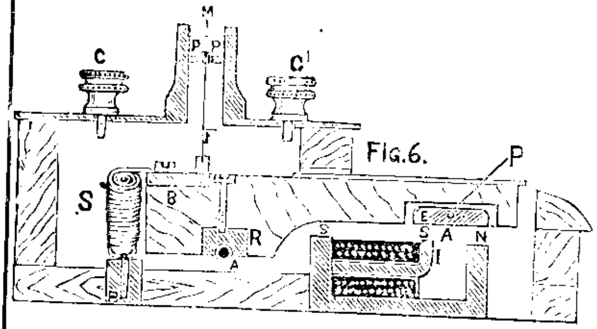


FIG.6.

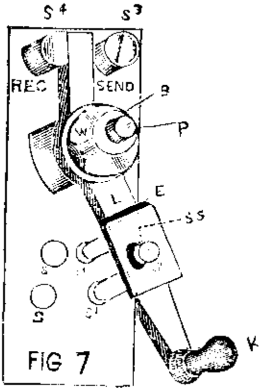


FIG 7

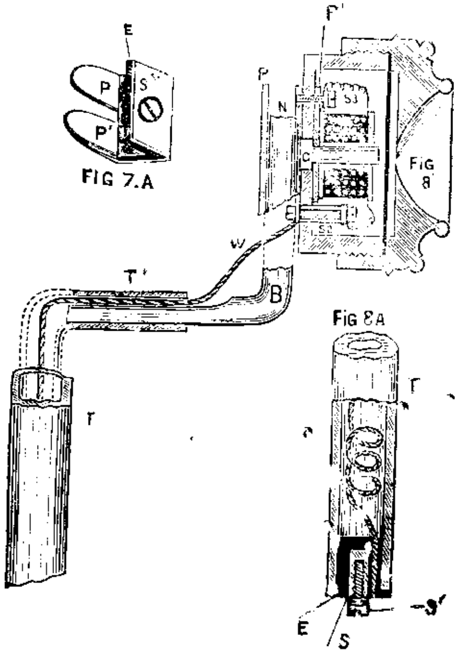


FIG 7.A

FIG 8

Fig 8A

CHAPTER III.

THE BAUDOT RELAY.

37 It was mentioned in Chapter I (paras. 14 and 15) that the incoming impulses are received on a relay which works the electro-magnets of the *Receiver* through the distributor in a local circuit. There are several novel features in the construction of the Baudot Relay, *e. g.*, the armature, its pivotting, the relation of the coils to the armature. *etc* : these and other points will be detailed later in this chapter.

The use of a relay in the Baudot system, like most other systems, does away with the need for transmitting strong currents over long distances. In the Baudot system the reversals are so rapid as to last for only $\frac{1}{42}$nd of a second. It is therefore necessary for the incoming current to produce the maximum effect in such a short space of time, that the relay should, (*a*) be constructed so that the current reaches its final value almost immediately, in other words that the *inductance* of the relay should be very low, and (*b*) that the moving parts of the relay should respond to weak impulses. The Baudot Relay is constructed to meet both these requirements.

38. Two horse-shoe permanent magnets M and M^1 (figs. 9 and 12) are fitted to a brass block B (figs. 10, 12 and 13) by means of a bolt B^1 and locknuts L L which secure them so that the similar poles are adjacent and hold firmly between them, each a soft iron pole-piece P (figs. 9 and 12). A soft iron screw S^3 which is adjustable (figs. 9, 12 and 14) passes through the pole-pieces, and is terminated in a highly tempered sharp point which acts as a pivot. The screw S^3 which may be termed the *pivot screw* is secured firmly in the pole-piece by means of a smaller screw S^4 (figs. 12 and 14) working into a slot cut into the screw S^3.

39. The beam or axle of the armature is specially designed and consists of a solid cylinder made up of three distant parts A B and C (figs. 9 and 18). The central portion consists of a piece of brass B, about ½ an inch in length, screwed into two pieces of soft iron A and C, one on either side of it The section marked C is a trifle more than the length of A and B combined, and carries a flat piece of soft iron I (figs. 12 and 18) which is fitted horizontally exactly in the centre of the whole beam or axle and at right angles to it. Directly above the armature is vertically fitted the tongue of the relay, which consists of a light brass upright U, about an inch in length, and which is mounted at the top with platinum (figs. 12 and 18). The whole of the above combination, the beam or axle, the armature and

At each end of the axle is drilled a hole into which small steel screws S S^1 (figs. 9 and 18) are inserted from underneath, and secured by means of brass clamping nuts, which are partially countersunk into the axle. The screw-heads themselves are well countersunk into the axle, and one of them S is drilled with a conical hole, whereas the other S^1 is cut in the shape of a broad V, similar to what would be produced by a three square file, if used on the screw-head. The screw-head S^1 is so placed in the beam or axle that the ridge of the V-cut forms a line parallel to the length of the axle. A novelty of design exists in the two screw-heads forming the bearings of the beam or axle. This arrangement obviates the need for the very accurate adjustment of the distance between the pivot screws S^3 (fig. 9), which would require to be at a fixed distance from each other if both the bearings were conical. The combined conical and V-shaped bearings thus ensure the armature being fixed directly over the cores, and at the same time admit of a small range of variation of the distance between the two supporting pivot screws S^3.

40 The coils are wound to a resistance of 100 ohms each, on two wooden bobbins, each of which is mounted on a square block of wood W (figs. 9, 12 and 13). The blocks W are provided each with two screw terminals to which are connected the ends of the coil. A groove G (fig. 9) is cut in the square block into which the yoke or sole piece for each coil, fits. The mass of iron in the cores is small. A complete coil with core and yoke is shewn in fig. 13 in which it will be seen that the core is attached to the yoke Y Y^1 which fits in the groove G (fig. 9) and supports the coil. The coils and cores can be raised or lowered by means of a screw S^5 (figs. 9, 12 and 13) which fits into the end Y^1 of the yoke. Cylindrical brass rods R form a continuation of the cores, and working into one of the guide holes G G (fig. 10) in the guide block, act as guides and help to keep the coils and cores vertical when they are raised or lowered.

41. The block B (figs. 10, 12 and 13) to which the magnets M M^1 are fixed and through which the guide rods pass is fixed to a brass base plate B^3 (figs. 9, 12 and 13), through which the permanent magnets M and M^1 pass. Each coil is supported over this plate by means of the adjustable screw S^5 (figs. 9, 12 and 13) and the guide rod R, which latter passes through a hole in the plate B^3 (figs. 12 and 13). Four body screws secure the plate B^3 to the wooden base on which five terminals are provided. Two of these terminals lead to the coils, which are connected in series, and the other three to the tongue and the contacts of the relay.

42 On each side of the permanent magnets is attached a brass arm or support A A^1 (fig. 12), a sketch of which is shewn separately in fig. 11. these supports are bolted to the magnets by means of brass bolts B^2 and locknuts L^1, L^1 (fig. 12). The bolts and nuts and the magnets are insulated from the supports by means of washers

E E and bushes of ebonite B^4 (fig. 12) ; the bolt passes through an opening S^5 (fig. 14) in the pole-pieces and helps to keep the latter firmly held between the magnets.

43. In the arms A A^1 are fitted contact stops CC^1 shown separately in figs. 16 and 17. Each contact stop consists of two separate screws, one of which S fits concentrically into the other S^1 (figs. 16 and 17). The screw S is called the *contact screw,* and its shaft consists of a brass rod R provided with a few worms R (fig. 17) near the head. These worms work into corresponding threads T provided inside the hollow head of the screw S^1, which is termed the *adjusting screw* in such a manner that when S is driven well home into S^1, about ¼ of an inch of the brass rod and platinum tip of S protrudes, from S^1 (fig. 16) The adjusting screw S^1 is provided on the outside with a worm W^1 which works into suitable screw-tapped holes in the supports A, A^1 (fig. 12). To keep S^1 firm in its place a locking or jamming device is provided in the form of a link L (fig. 15) through which also the screw S^1 passes. The link L is fitted with straining screws S^2 (figs. 12 and 15). When S^2 is not strained the screw-holes of the link L and the support A or A^1 are fairly concentric, and the screw S^1 is free to turn in them ; but when S^2 is tightened, it has, by pressing against the arms, A A^1, a tendency to draw L away from the supports, and consequently to make the screw-holes of L less concentric with the holes of the support A or A^1 with the result that S^1 is strained laterally and is jammed in position. It will be seen from the above that the contact screw S can be withdrawn without affecting the position of the adjusting screw S^1 (fig. 12). The points of contact both of the tongue and the contact screws should be kept perfectly clean and square so as to allow maximum surface to be presented in the formation of contact and thus to considerably reduce sparking.

44. The compound axle (figs. 9 and 18) by resting on the soft iron pivots S^3, which are in connections wlth the pole-pieces becomes polarised and forms an extension of the poles ; a closed magnetic circuit would be thus formed, but for the section of brass B (figs. 9 and 18) which is inserted in the axle. In the section A of axle adjacent to B South polarity is induced and in the section C, likewise adjacent to B, as well as in the armature I attached to C, North polarity is induced. The North polarity of the armature I is considerably strengthened by the proximity of the South polarity of the section A. Thus, by giving a T-shape to the combined armature I and section C of the axle, consequent poles are produced in the armature, both ends of which are of North polarity.

The passage of a current through the coils causes the upper ends of the cores to be polarised oppositely. The resultant effect therefore is the repulsion of one and the attraction of the other end of the armature on which both coils act ;

The figure of merit of the relay is 0·5 milliampere. For quickness of action combined with sensibility, it is essential that the play of the tongue and hence of the armature should be very small, and that the cores of the electro-magnets should be as close as possible to the armature. These adjustments can be regulated by the contact and adjusting screws, and by raising or lowering the coils, the latter being independent of the pivotting of the axle.

45. A vertical brass lever V (fig. 9) called the *bias lever* is fitted in front between the two permanent magnets. It is pivotted by means of a small screw S^6 around which is fitted a small spiral spring, the pressure of this spring against the lever keeps it steady in whatever position it is placed. To the upper extremity of the lever V is attached one end of a delicate brass spiral spring S^2, the other end of which fits on a hook H attached to the tongue of the relay. By means of this lever and spring, a small bias can be given to the tongue to one side or the other. It may be mentioned that in putting the lever to the side of the marking contact care should be taken that the brass spring S^2 (fig 9) does not touch the support A (fig. 12), else the contact points and the tongue will be thrown out of action, due to the short circuit thereby produced. The effect will be the same as when a permanent marking current is sent through the relay coils.

46. In obtaining the correct position of the axle, armature and tongue, relative to the pivots, the cores and contact points respectively, the following points should be observed.

(*a*) The armature should be directly over the cores. A defect in this direction may be remedied by loosening the bolt B^1 (fig. 12) which secures the magnets to the block B and shifting the magnets so as to obtain the required position.

(*b*) The axle should be adjusted to move freely on the pivots. In effecting this the bolt B^2 (fig. 12) should be loosened and the pole-piece P (fig. 12) supporting the conical bearing placed so that the armature covers the cores; the pivot screw S^1 should then be adjusted so that the ridge of the V bearing is in line with the length of the axle. The point of the pivot should be at the centre of ridge. The rapid action of the relay depends on the perfect balance and pivoting of the axle, and care should be taken that the pivot points are clean, sharp and firm.

(*c*) The axle should be clear of the pole-pieces and parallel to them. The space between the axle and the pole-pieces should be equal to about one thickness of a sheet of message form. This space should be uniform along the length of the axle. Irregularity in this respect will be due to one of the pole-pieces or pivots being above the other. To remedy this the pivot points should be raised or lowered by loosening the small clamping screw S^4 (fig. 12), and by working the screw S^8 up or down, as required; the clamping screw

The above adjustments permit of the maximum electro-magnetic effect being obtained. In performing the adjustments the position of the points of the contact screws C C^1 in relation to the hammer head of the tongue should be also obtained. This is effected by loosening the bolts B^2 and shifting the supports A and A^1 until the contact points are perfectly in line with the hammer head of the tongue.

Occasional verification of the above mentioned points is necessary, and this verification is absolutely necessary whenever a new relay is brought into use.

47. For the purpose of cleaning the contacts of the screws and tongue a rectangular metal block B (fig. 20) is provided. When cleaning the tongue contacts the axle should be placed in the groove G provided along the length of the block, so that the tongue lies in the position indicated by the dotted line; then keeping the armature pressed with the finger, the emery stick should be rubbed flat on the block. The pressure of the finger on the armature brings the hammer head which is thus held perfectly square, into contact with the emery stick. To clean the screw contact points, the screw should be let into the holes H provided for them in the block. The block should then be placed on a sheet of emery paper and a rotary motion communicated to the head of the contact screw. The use of the block ensures a practically plane surface and permits of the maximum surface of the contacts being brought into play, thus reducing to a great extent sparking at break of contact. The emery used must be very fine, preferably No. 000.

48. A very good practical method of adjusting the relay is as follows. With no current passing through the relay coils and the clamping screws S^2 of the square link L (fig. 12) loosened, the tongue should be brought to rest on one of the contact screw S the other contact screw being carried out. The adjusting screw S^1 of the former should then be screwed in till the tongue flies off the contact; S^1 should next be unscrewed a little, till the tongue when replaced on this contact just rests on it. The clamping screw S^2 of the link L should then be tightened, thus jamming the adjusting screw S^1 in the position obtained. The contact screw may now be removed without altering this adjustment. The operation should be repeated for the other contact screw. In performing these adjustments care must be taken that the contact screw S is driven well home on to the head of the adjusting screw S^1.

If the above adjustments have been carried out properly, the contact screws when driven home into the adjusting screws will give the tongue a very small play, and further, the tongue will rest on either contact when placed there, *i e.*, it will have a neutral bias; should however the play be large the distance between the cores and armature needs raising the coils. Too small a play indicates that the coils and cores are very close to the armature and *vice versa*. The following tests indicate the correct adjustment of the relay.

(*a*). With the tongue held perfectly perpendicular by being jammed between the contact screws, the coils should be raised or lowered by means of the screw S^5 (figs. 9, 12 and 13) until four thicknesses of message form will just pass between the armature and the coils.

(*b*) After the contact points have, been adjusted as indicated in para. 48 above, one thickness of message form should just fit in between the contact screws and tongue.

(*c*). The screwing of either contact screw half a turn outward should bring the armature on the core.

49. Faults in the relay are of rare occurrence, with the exception of those due to unequal currents circulating in the coils and producing a bias either to 'marking' or 'spacing.' In practice it may occur that extra positive impulses are apparently operating the relay, resulting in erroneous printing. To prevent this, the right or 'spacing' *adjusting* screw C (fig. 12) should be withdrawn a very little, and the left or 'marking' *adjusting* screw C^1 advanced to keep the play unchanged. A failure of positive impulses will require an opposite adjustment. This is practically giving to the relay either a small *spacing* or *marking* bias. These extra impulses or failures of impulses may be due to line conditions; but as they may also be due either to a weak negative or positive current respectively, and as there is a practical limit to the counteracting adjustment of the relay in the manner described above, the battery power at the distant station should be regulated so as to equalise incoming currents. The current impulses obtained by signalling the letters T and G alternately are utilised in obtaining the adjustment of the relay. Referring to the Baudot Code (fig. 1) it will be seen that this consists practically in sending reversals through the relay. A perfect record of T G's on the Receiver proves that the relay is in the state of sensibility necessary for rapid action.

50. To ascertain whether the arriving currents are passing through the relay, place the finger lightly on the armature, and judge by touch whether it is being regularly drawn over. In doing this care should be taken that the pressure of the finger does not affect the working of the relay tongue. A still more efficient means of ascertaining the action of the armature consist in the application of a screw-driver to the link L (fig. 12) on the marking side of the contacts, the ear being placed on the handle of the screw-driver. The sound of the impacts of the tongue against the contact screw will thus be sensibly conveyed to the ear through the screw-driver and will indicate whether the arriving current is actuating the relay. In addition to

DIAGRAM—CHAPTER III.

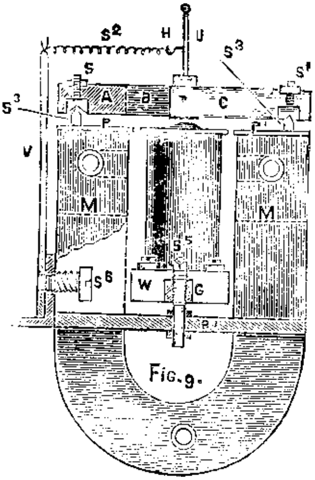


Fig. 9.

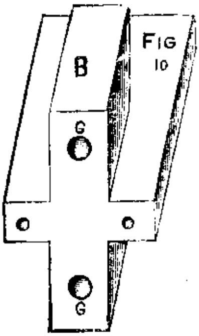


Fig 10

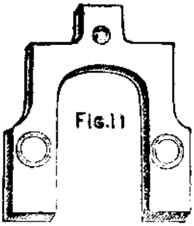


Fig. 11

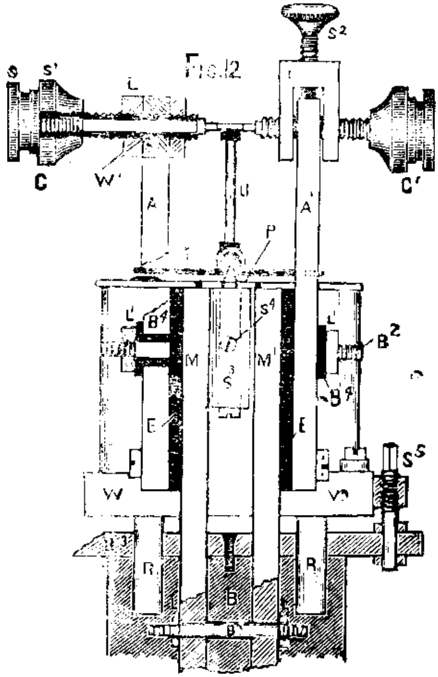


Fig. 12

DIAGRAM,—CHAPTRE III—*(concld.)*

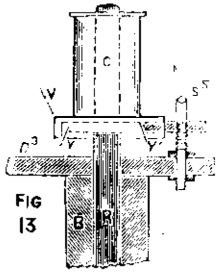


FIG 13

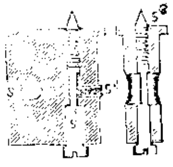


FIG. 14.

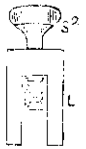


FIG. 15

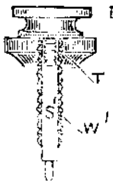


FIG. 16

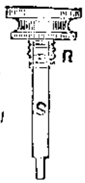


FIG. 17.

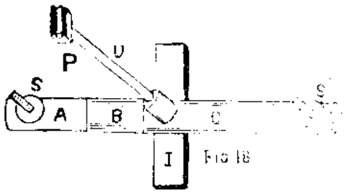


FIG 18

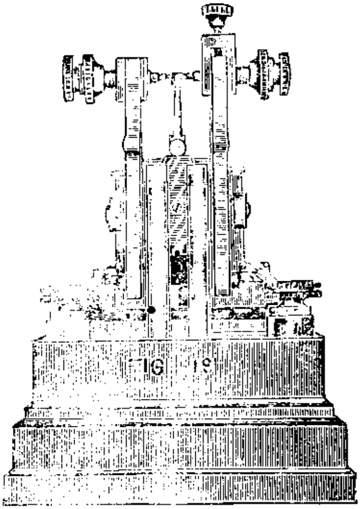


FIG 19

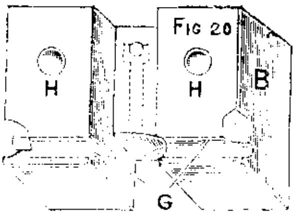


FIG 20

Chapter IV.

DRIVING GEAR.

52. Two important instruments in the system have now to be described, *viz*, the Distributor and the Receiver, but before proceeding with their description, it is necessary to detail the means adopted to provide these instruments with their motive power, as their proper functioning depends greatly on the accurate rotation and movement of their parts.

The clockwork train by which the motive power is communicated to the Distributor and Receiver is practically the same in both instruments. A description of the driving gear of the Receiver only, will therefore be given in this chapter.

The wheels with their pinions are held in position between two plates, only one of which F, the front plate, may be seen (figs. 21 and 22), the back plate having been removed to give a better view of the parts. The plates are held together by screws which are driven into four brace blocks B, B^1, B^2, and another not shewn in the figure. Steady pins are also used to keep the plates accurately in position.

The bearings of the axles of the wheels are drilled into circular steel bushes, which are set into the plates and fixed by suitable screws. It is a notable feature of the Baudot apparatus that wherever wheels and pinions are employed, steel axles almost invariably work in steel bushings. The object of this is to ensure very accurate setting and to reduce wear and tear of the pivots and bearings by making the rubbing surfaces as hard as possible.

53. The clockwork may be divided into two parts, *viz.* the *winding* and the *driving* gear.

The winding gear.—On an axle A (figs. 21 and 22) are loosely threaded two blocks B^3 and B^4. The block B^3 is provided with a spiked wheel W fitted in the middle of it and a detent D adjacent to the block B^4. To this detent is attached by means of a screw S (fig. 22) one end of a small ratchet or click R (figs. 21 and 22). The block B^4 consists of three wheels cast solid with the block, one of which W^1 is spiked and cast between the other two *ratchet* wheels W^2 and W^3. The ratchet or click R on the block B^3 is provided with three teeth which work against the teeth of the ratchet wheel W^2 and is held there by means of a flat spring S^1 (fig. 21) which presses against a pin projecting from the ratchet R. Another ratchet or click R^1 (fig. 23) works against the teeth of the ratchet wheel W^3. The above appliances, *viz.*, the axle A with the two blocks B^3 and B^4, consisting of the wheels W, W^1, W^2, and W^3, the detent D and the two ratchets R and R^1, constitute the *winding* gear, as they come into play only when the weight has to be raised. The block B^3 as indicated by the double-headed arrows can be moved in either direction, but the block B^4 can be moved only in the direction indicated by the single headed arrows (figs. 21 and 22).

The driving gear, which comes into play only when the weight is running down, consists of five wheels and pinions, numbered from 1 to 5 (fig. 22). In the fall of the weight the chain travels over a pulley P and then over a spiked wheel W^4 (fig. 21) fitted on the same axle as wheel 1 (fig. 22) which is thus set in motion. The order of gearing of the wheels and pinions is shewn numerically in fig. 22 in which their direction of rotation is also indicated by small arrows. The view (fig. 22) is from the back of the Receiver and affords a good idea of the clockwork; the direction of rotation therefore is opposite to what it would appear if the front view was shewn. The five wheels 1 to 5 (fig. 22) with their pinions constitute the *driving* gear of the clock work.

54. Fig. 23 gives a rough sketch of the manner in which the driving chain gears with the wheels. Starting from the pulley wheel P (figs. 21 and 23) it passes over the spiked wheel W^4 and threading through the roller R^3 of the weights W^5, goes over the spiked wheel W^1 which is fitted on the block B^4 (figs. 21, 22, and 23) then through a counterpoise weight C back to the starting point.

55. Another smaller chain C^1 fitted at one end to an antagonistic spiral spring S^2 and at the other, to an iron rod R^2 gears with the spiked wheel W which is fitted on the block B^3 (figs. 21, 22 and 23) and is free to move in both directions. By the tension of the spiral spring S^2 (fig. 23) the detent D (fig. 22) is kept against the cylindrical brace block B^1, but when the chain C^1 is pulled in the direction of the dotted arrow, (fig. 23) by the depression of the pedal P^1 to which the rod R^2 is attached, the detent D is carried in the direction of the dotted arrow (fig. 21). When this happens the ratchet or click R (figs. 21 and 22), which is kept pressed against the ratchet wheel W^2 by means of the spring S^1, moves the block B^4, and connected wheels, W^2, W^3 and W^1 on which the chain is supported, along with it, thus raising the weight W^5 by drawing down the driving chain. On releasing the pedal, the spring S^2 (fig. 23) pulls the small chain C^1, which thus carries the block B^3 and the detent D to the normal position. In returning to the normal position the teeth of the click or ratchet R (figs. 21 and 22) just slide over those of the ratchet wheel W^2 on he block B^4 but the latter is held firmly by the ratchet or click R^1

(fig. 23) which engaging with the teeth of wheel W^4, keeps the block from moving in the reverse direction. The chain of the raised weight is thus held in position on the wheel W^1 between the ratchet wheels W^2 and W^3 (figs. 21 and 22) and the weight is maintained in position. On release the upward motion of the pedal, under the action of the antagonistic spring S^2 is stopped, by the detent D being arrested by the lower side of the cylindrical brace block B (fig. 21). The small chain C^1 should be fitted on the spiked wheel W so that normally at rest the detent D should be just touching the lower side of the brace block B^1 (figs. 21, 22 and 23). This adjustment will allow of the pedal P^1 being lowered to its full extent and also of being stopped at a certain point in its upward rise, and thus kept from striking against the foot-rest, which lies directly above it.

56. It was mentioned in para. 53 that wheels 1 to 5 (fig. 22) constitute the *driving* gear. When the Receiver is started these five wheels are set rotating and their motion is communicated to the typewheel by means of a sixth wheel and pinion 6 (fig. 24). Over the frame of the clockwork is fitted a brass plate P^3 (figs. 23 and 24) the chain in stretching across from the pulley P to the wheel W^4 passes under a steel guide roller G attached to P^3. This guide or *chain roller* as it is called presses against and revolves with the movement of the chain thus steadying its action and helping the links to fit firmly on the spikes of the wheel W^4. Above the brass plate P^3 (fig. 24) are fitted two brass blocks B^5 and B^6 bushed with steel. Into these the spindle of the sixth or last wheel 6 of the train gears. This spindle carries the speed regulator or *moderator* as it is called and is also provided with a brass fly-wheel F against which a cork brake can be applied by means of a brass lever which acts as a starter. A full description of the above and its attachments will be given in Chapter VII.

57. At the bearings of all the spindles of the clockwork, oil vents are provided and small tubes lead to the top edge of the frame plate wherever necessary, corresponding vents are provided on the brass plate P^3 (fig. 24). The oiling can thus be easily done. The brass blocks B^5 and B^6 are similarly provided with oil vents.

58. The driving weight W^5 (fig. 23) consists of a rectangular block of iron with a hollow in the centre into which a pulley or roller R^3 is fitted by means of a pin which passes through the mass of the weight and on which the roller revolves. Under the block W^5 is fitted the additional weight pan. This consists of a sheet of iron I bent over on two sides of the block and fitted to it by means of the screws S^3. A rod R^4 is fixed to the sheet I and terminates in a round plate P which may be called the *pan*. Rectangular slabs of lead L provided with slits to slide across the rods R^4 and weighing about 25 lbs. each are placed on the pan

in a manner similar to that of weigh bridges. To keep these slabs from tilting over and falling out, when the weight is raised, hemispherical hollows H (fig. 23) are cut on the upper and lower surfaces of the slabs. The pan P^2 itself is provided with a hemispherical projection to fit into the hollow on the lower surface of the first or lowest slab. Into the hollow on the upper surface of this slab is placed a lead ball B the upper half of which likewise fits into the hollow in the lower surface of the second slab. These slabs are thus piled on until the required number is obtained. Generally three slabs are sufficient for the driving gear of the Distributor and two for that of the Receiver.

59. In order to prevent the weights from being raised too high, a portion of one of the upper corners is cut away, and a spike or detent S^4 fixed, so that when the weight rises to a certain height the spike S^4 enters into one of the links of the winding chain C and prevents the rise of the pedal by obstructing the recoil of the distended antagonistic spiral spring S^2. The operator is thus prevented from raising the weight beyond a certain height. As the weight descends the spike S is disengaged from the chain and the spiral spring draws up the pedal to its normal position.

60. The two ends of the driving chain, which is similar in pattern to that generally used in bicycles, are fitted together by a screw. To place the chain in position this screw should be removed and one end of the chain passed over the pulley P and the spiked wheel W^4, then under the roller R^8 of the weight W^5, over the spiked wheel W^1 and through the counterpoise weight C back to the pulley P. The counterpoise weight helps to keep the chain between the pulley P and the wheel W^1 taut and thus ensures the links fitting firmly on to the spiked wheel and holding the weight securely. In passing the chain under the roller R^8 the axle and roller have to be removed and the chain being passed around the roller, the latter is put back in position and the axle driven home.

61. In addition to the pedal, an automatic lift is provided. This is actuated by a small electric motor of about 0 15 horse-power. The electrical circuit of this motor is controlled by a make and break circuit switch. This consists of a brass lever L^1 (fig. 23) mounted on a wooden base and pivotted at a point P and which carries a flat steel spring S^5. This spring is provided with a block K which works between two brass studs S^6 and S^4. The block K and the stud S^7 are faced with platinum and close the circuit of the electric motor whenever they are brought into contact with each other. One end of a small brass chain is connected to an ebonite block E fitted to the lever L^1, while the other end is connected to a flat steel spring S^8 fitted to the weight. Normally the block K is held against S^6, but as L^1 is pulled by the descending weight the spring S is bent in the opposite direction, and buckles smartly

across to the position indicated by the dotted line, thus placing K and S in connection with each other, and closing the circuit of the motor which is started. As the weight is raised by means of the electric motor and the automatic lift, it engages with a wooden cylindrical knob K^2 fitted at one end of the lever L^1, which is thus pushed up and returning the block K to normal position against the stud S breaks the circuit of the electric motor. A small brass stud S^9 is fitted near one end of the lever L^1 and prevents it from being drawn over too far, and thus destroying the spring S^6. If for any reason the electric motor fails to act, the weight in continuing its descent would snap the connecting brass chain C^2, but this is prevented by the action of the flat spring S^8, which bends as indicated by the dotted line until the weight is brought to the ground. The length of the chain C^2 should be such that when the weight is resting on the ground the flat spring S^8 should be appreciably bent upwards, as indicated by the dotted line, otherwise the weights will not be able to actuate the lever L^1 efficiently, and in consequence the motor circuit will not be closed.

The automatic gear consists of a pulley wheel P^4 fitted on an axle A^1, one end of which is provided with a tangent screw T. This screw gears tangentially with a toothed wheel W^6 fitted loosely on one end of an axle A^2 to the other end of which a small spiked wheel W^7 is rigidly attached. The pulley P^4 is connected with the pulley P^5 of the electric motor by a leather band and when the motor is started, the spiked wheel W^7 is rotated by means of the connecting tangent screw and wheel W in the direction indicated by the arrow. The wheel W^7 is so fitted that the spikes engage the links of the chain to the right of the counterpoise weight C and draws the chain downwards thus raising the weight.

The axle A is provided with a collar C^3 into which a notch N is cut (dotted lines, fig. 23). A pawl P^6 and spring are so fitted on the wheel W^6 that when the latter rotates in the direction indicated by the arrows the pawl fits into the notch N and locks the wheel with the axle A^2, thus driving the latter round. If from any chance the wheel W is driven in the opposite direction, the pawl slips over the collar and the axle A^2 is thrown out of action. The spiked wheel W^7 is thus automatically prevented from rotating in a direction opposite to the arrow and thus destroying the direction of the revolution imparted to the driving gear by the weight W .

62. The speed of the Distributor brushes and of the Receiver type-wheel is maintained at close on 180 revolutions a minute. The sixth spindle of the driving gear of the distributor on which the regulator is fitted is arranged to revolve at about seven times this speed, *i. e.*, about 1260 revolutions a minute (ratio between brush axle and sixth spindle 1 to 7). The sixth spindle of the Receiver on which the moderator is fixed rotates at from 1800 to 1830 revolutions a minute. It will be seen from the above that the

spindles on which the speed governors, *viz.*, the *regulator* and the *moderator* in the Distributor and Receiver respectively, are fitted, are kept revolving at a very high speed with the object of giving considerable momentum to the clockwork, and thus guarding against any momentary diminution of speed due to friction, insufficient lubrication or other cause, being felt.

63. The following points should be observed to maintain the driving gear in good order.

(*a*) Care should be taken to keep off foreign matter such as fine particles of brick-dust, emery, etc., from the bearings of the wheels.

(*b*) The bearings should be oiled frequently by means of the oil vents, to ensure smooth and accurate rotation of the wheels. In this respect a little oil in excess is a fault in the right direction. To ensure efficient lubrication the tubes leading from the bearings should be cleaned occasionally. The oil used for the Baudot apparatus is of a special quality , it is very thin and provides efficiently the necessary lubrication. The use of most other oil causes clogging and inaccurate running of the clockwork.

(*c*) The pulley P, the guide roller G, and the weight pulley R^3 (fig. 23) should work freely on their respective axles.

(*d*) The ratchets or clicks R and R (figs. 22 and 23) should press firmly against the wheels W^2 and W , respectively, a harsh noise heard in winding is due to the ratchet spring being too strong.

64. A fault of frequent occurrence is the working out of the chain screw. A fault of this nature is troublesome as it requires constant attention. If it is due to a loose screw, the screw should be changed. Care should be taken to always drive the screw firmly home. The working out of the chain screw causes a jam of the clockwork train by the chain getting caught either in the automatic lift by the spiked wheel W , or by the spikes of the wheel W^4 near the guide roller G.

When machines are in daily use, once in three months the driving gear should be taken to pieces; all parts should be thoroughly cleaned at least once in four or six weeks. The axles and bushes should be polished *when necessary* on a lathe, by means of an emery buff stick (No 000) and then burnished. When the driving gear is taken to pieces the axles and bushes should be carefully burnished. The slightest friction in the bearings of the axles causes great variation in speed and must be avoided. In the event of considerable polishing and burnishing being necessary, the work should be entrusted to a good clock repairing firm. The wheels and pinions should be examined and any burrs removed by means of a topping file.

The chain should also at the time be carefully cleaned. Every kink of it should at all times be perfectly free and supple. A defect in this is chiefly shown by the chain getting caught at the wheel W^7 of the automatic lift.

The weight pulley R^3 should always move freely on its axle.

With proper maintenance the driving gear gives little or no trouble, and all that is necessary is a little care and mechanical skill

CHAPTER V.

THE RECEIVER.

65. It was mentioned in Chapter I, paras. 9 and 14, that a Receiver consisted of five electro-magnets worked in the local circuit of a relay, and suitable electrically controlled mechanism to imprint the necessary characters on tape. A description of the above will now be given.

66. The framework of the Receiver consists of two brass plates B and B^1 (fig. 25) which are held firmly together by means of screws fitted into brace blocks. The clockwork consists principally of two wheels W and W^1 (fig. 26). Wheel W revolves freely on an axle A^1 which is rigidly fixed to the front plate B^1 by means of a screw S^1; and wheel W^1 is rigidly fitted on the axle A (figs. 26 and 28) which carries the typewheel.

Wheel W in addition to gearing with W gears also with the pinion 6 (figs. 24 and 26) of the sixth spindle of the driving gear, and the rotation of the driving-gear clockwork is thus communicated to the clockwork and typewheel.

67. Five electro-magnets E (figs. 27 and 28) are fitted horizontally on the upper part of the Receiver in the following manner. On one side, each electro-magnet E is fitted to a common ebonite block B (fig. 28) which is screwed on to the back plate B^1 (fig. 28), and on the other side to a brass plate B^2 which forms part of a square bracket fitted on to the front frame plate B^3 (fig. 27) of the Receiver.

The cores are provided with pole-pieces P and P^1 in front and rear (fig. 28); to the rear pole-pieces, P^1, of each of the electro-magnets is hinged a soft iron armature K (figs. 27 and 28). The coils are wound to a resistance of 50 ohms and on the same bobbin a second coil is wound over the first up to a resistance of 200 ohms. This second winding is used as a shunt to the first, which in addition to prolonging the action of the primary current at break of each signal eliminates sparking at the relay contacts and distributor segments. The parallel resistance of each coil and shunt is about 40 ohms.

68. The ends of the coils adjacent to the pole pieces P (fig. 28) are connected through these pole pieces to the framework of the Receiver, which is always connected to earth through the base plate P^3 (fig 24). The other ends of the coils are joined to screws fitted on the ebonite block B (figs. 27and 28) and from these screws separate insulated leads are carried to the terminal contact springs.

69. There are 7 brass *contact springs*, C^1 to C^7, (fig. 25) which are fitted by means of screws to an ebonite block E^1. The 5 springs C^2 to C^6 are connected one to each of the 5 electro-magnets E (figs. 27 and 28 by means of insulated wires, and the springs C^1 and C^7 are connected through a contact-making device to earth. The object and action of the contact-making device which is employed for maintaining synchronism between the Distributor and Receiver, will be explained in Chapter VII.

70. When the Receiver is placed in position on the base plate P^3 (fig. 24) the contact springs C^1 to C^7 are placed in connection with 7 brass studs S^1 to S^7 which are fitted on an ebonite block E^2 (fig. 29) and are connected to the segments of the distributor. On the frame plate P^3 (fig. 24) is provided a screw to which the earth wire is led as shewn at E (fig. 29). The details of these connections will be given in Chapter VII, but it may be noted here that by means of the spring contacts C^1 to C^7 the Receivers can be easily detached and changed without the need for undoing any connections.

71. A brass lever L (fig. 30) called the *balance lever* is pivotted at a point P on the back plate of the Receiver directly below the five electro-magnets. One end of L terminates in a sharp tooth T while the other is provided with a pin P^1 which passes through it. Two flat springs F, F^1, provided with german silver contacts G, G^1, are fitted on an ebonite block E^3, parallel to each other, and placed below the lever L. The spring F is permanently in connection with earth through the frame of the Receiver. Normally, the spring keeps the lever L against a cam which consists of an eccentric collar C fitted on the axle A (figs. 28 and 30). When the Receiver is set in motion and the axle A revolves, the point P^2 of the cam pushes the end T of the lever L upwards and the corresponding pin P^1 at the other end presses on the spring F and puts it in contact with F^1. The latter is connected to the brake electro-magnet M, through the contact spring C^7 (fig. 25) and stud S^7 (figs. 29 and 30). The brake electro-magnet is thus earthed once in each revolution and the circuit of the local battery B (fig. 29) is closed through it. On release, the spring F breaks away from F^1, but is kept from rising above the horizontal position by means of a pin P^3 which is sheathed with ebonite and fitted directly above it. The elasticity of the springs F and F^1 should be such that when the collar C is in the position shown in fig. 30, a break of circuit between G and G^1 is always ensured. The further action of this contact-making device will be described in Chapter VII.

72. Beneath the armature K (fig. 28) of each electro-magnet is fitted a flat brass spring F, divided into two prongs at one end; these prongs rest on ledges L on the front pole-piece P and normally keep the armatures K away from these pole-pieces. When however, a current is sent through the electro-magnets, the

armatures are brought down over the front pole pieces and the brass springs F serve as anti-contact surfaces. It was mentioned in para. 67 that each armature is hinged to the back pole-piece, and consequently forms a continuation of the core; when the armature is drawn downwards under the action of a current, a closed magnetic circuit is thus formed and the maximum electro-magnetic effect is ensured.

73. A strip of springy brass L^2 (figs. 27 and 28) called the *appendix* is attached to the upper surface of the armature K by means of a screw S^1. The free end of L^2 projects beyond the free end of the armature K, and is bent so as to be clear of the spring F^1 (fig. 28) when the armature is attracted. To regulate the distance between the armature and the appendix a *notched screw* N (figs 27 and 28) passes through the latter and works in the armature. A small pin P^7 enters one of the notches in the head of N and keeps it from working out, which would otherwise result from the constant up and down action of the armature and appendix. The spring F (fig. 28) keeps the appendices L^2 normally pressed against a brass bar B^4 (fig. 27), which is fitted above the appendices and regulates their play by means of five adjustable screws numbered 1 to 5. The appendices in their rest position are adjusted by means of these so as to be all in the same horizontal plane.

74 Directly below each appendix is vertically fitted a flat steel spring F^1 (fig. 28); the lower end of this spring is provided with a knife edge block K^2 which is attached to the brass plate B_2 by means of two adjustable screws.

The bent ends of the appendices L^2 normally overhang the horizontal arms of 5 bell crank levers A^1 (figs 27 and 28) termed the *appendix levers.* These levers are pivotted loosely on an axle A^3 and have a to and fro motion on it, independent of each other. Normally the end of the horizontal arm of A^1 (fig. 28) rests in a V-shaped notch in a brass head H fitted at the upper end of the spring F^1; but when the armature is attracted, the bent end of the appendix pushes the lever A^1 into the position shown by the dotted lines. The tension of the *appendix lever spring* F^1 which is regulated by the screws on the block K^2 is adjusted so as to retain the lever A^1 in either position shown in (fig. 28) until it is driven to the opposite position by the action of either the appendix or of a *shuttle* which will shortly be described. The *electrical* action of the Receiver terminates here, and what follows is purely *mechanical.*

75. To the wheel W^1 (fig. 28) termed the *combiner wheel* is fitted a ring of brass R; a section of R is cut away and in its place is fitted a *shuttle* S^2, a portion P^2 of the shuttle lies outside the ring R, and in line with the edge of it a small flat steel plate S , called the *guard plate*, is fitted to the ring R by means of two screws, which lie about a quarter of an inch below the outer circumference of R. These screws are provided

with collars to keep S^3 at a certain distance from R and in line with the edge of P^2. Normally the vertical end V of each appendix lever A^1 stands clear of the guard plate S^3 and the ring R; but when under the action of the electro-magnets the appendix lever is placed in the position indicated by the dotted lines and the wheel W^1 is rotated, the end V of A^1 is driven up against the ring R and is taken up by the guard plate and driven inward by the part P^2 of the shuttle until it strikes against the axle A^2 of a pin P^3, called the *combiner pin*. After this it follows the course of the dotted line and is ejected by the portion P^4 of the shuttle. The impetus of ejection replaces the lever A^1 in the normal position.

76. The *combiner pin* consists of a bent lever P^3 (shown separately at Q) provided with a collar C^1, which forms part of it and is rigidly fixed to the axle A^2 by means of a small pin driven through both. There are five such *combiner pins* (fig. 31) fitted on similar axles. The pins are provided with hammer heads H^1 (figs. 28 and 31), which are adjacent to each other and lie directly above their axles; but the feet, which are sometimes called *seekers*, are bent away from their axles and jointly form an arc of a circle as may be seen in fig. 31.

77. Two circular plates (fig. 28) P^5 and P^6 known as *combiner plates* are fitted to the front of the wheel W^1 by means of three screws. A circular disc of steel D about $\frac{1}{32}$nd of a inch in thickness separates W^1 from P^5 and a similar disc D^1 lies between P^5 and P^6. The diameter of the discs D and D^1 is about one-sixteenth of an inch greater than that of P^5 and P^6, and ridges are thus formed by them on either side of P^5 and on the inner side of P^6. The feet of the combiner pins P^3 which normally rest on the periphery of P^5 are kept in position by these ridges.

A section S^4 of the ridge on D^1 and P^6 is cut away, as indicated by the dotted lines, and a cam K^3 termed the *replacing cam*, is fitted on the combiner wheel W^1 directly opposite the section S^4.

When the vertical end V of the appendix lever A^1 strikes the axle A^2 of the combiner pin P^3 and drives it forward, the foot of the pin, which lies a little to the right of the centre of the axle, is exactly opposite to the point P^8 of the *combiner plate* P^6. Since at this point the ridge formed by the disc D is cut away, the pin with its axle is driven forward, and its foot is made to rest on the *forward* combiner plate P^6 for nearly a whole revolution of the wheel W^1, until the cam K^3 replaces it on the *back* plate P^5. The forward drive and replacement of the appendix levers are indicated by the arrows below and above K^3 (fig. 28), the heads of which indicate where the changes take place.

78. The ends of the axles of the combiner pins work in bearings in two steel plates. The combiner pins P^3 admit of a dual motion *viz.*, (*a*) that of being driven independent of each other, backward and forward together with their axles, in the direction

indicated by the double headed arrow (fig. 28,) and (*b*), that of dipping down with a lateral motion to the right. The heads H^1 (fig. 31) of the combiner pins lock into each other like the key-stones of an arch; the second action of dipping can therefore only be effected by them collectively and never independent of each other.

The peripheries of the combiner plates P^5 and P^6 are constructed with broad V-shaped indentations which are arranged so that no two indentations on the two plates are opposite each other. In (fig 32) the plate P^5 is shown smaller than P^6 with the object of showing how the indentations on the two plates are arranged relative to one another; it must, however, be borne in mind that the two plates are of the same dimensions. The section K^3 of the plate P^6 indicates the point where the replacing cam is fixed.

For purpose of easy reference the peripheries of the combiner plates P^5 and P^6 will be hereafter termed the *back* and *forward grooves*

79. Recapitulating the sequence of operations performed, it has been seen how the appendix levers, when struck by the appendices of the electro-magnets, drive forward the combiner pins, and how the feet of these pins are arranged in various positions on the combiner plates according to the number and sequence of the electro-magnets worked. It was also seen that the combiner pins which are driven forward are replaced in their normal position after each cycle by a replacing cam K^3 (fig. 28). It now remains to be seen how these combiner pins control the type-printing machanism.

80. If the combiner pins that are pushed on to the *forward* groove correspond to positive impulses and those that remain on the *back* groove correspond to negative impulses, it may easily be understood how these pins could under the action of the controlling electromagnets be made to take up positions corresponding to the combinations of the Baudot Code. Again if the indentations on the peripheries of the combiner plates could be so arranged as to admit of a dipping action of the feet of the combiner pins, once in each cycle, at various points on the back and forward grooves for various combinations of the combiner pins, it will be possible to arrange type on a wheel, revolving on the same spindle as the combiner plates, and so utilise this dipping action of the feet of the combiner pins as to actuate the printing mechanism, just as the letter corresponding to a particular combination of pins is passing a certain point. The construction of the printing mechanism is based on this principle.

81. It will be seen (fig. 32) that the maximum number of consecutive indentations on the back combiner plate P^5 is 4, whereas that on the forward plate P^6 is 5. There is obviously therefore no position on the back plate into which the *five* combiner pins could dip together, consequently when all the electro-magnets are at rest

i.e., when only negative impulses are being received, the combiner pins will never dip.

In the forward plate the 5 consecutive indentations correspond to the letter P, which is impressed when all the five electro-magnets are actuated by 5 consecutive positive impulses.

82. On the axle A^1 (figs. 31 and 34) to the left of the frame work adjacent to the first combiner pin is fitted a lever B^1 (figs. 27 and 34) which is similar in shape to the combiner pins but is not provided with a lower foot or seeker. This lever has only one movement, *viz.*, the lateral or dipping motion of the combiner pins. The head of B^1 (fig. 27) is placed so that three-fourths of it is normally in contact with the head of the adjacent pin ; thus when the foot of the first combiner pin is on the back groove its head is about a quarter behind the head of B^1 and when in the forward groove, a quarter in advance. The axle A^1 projects through an aperture A^2 in the front frame plate B^1 of the Receiver (fig. 25) and to the projection is fitted a lever L (fig. 34) termed the *propelling lever.*

83. One end of a flat spring S (fig. 34) is attached to the lever L and the other end presses against an adjustable screw C (fig. 34 and 38) passing through the frame plate of the Receiver. The pressure of the spring S is communicated to the propelling lever L and through it to the lever B^1 (fig. 34) in such a direction as to keep the head of the latter pressed against the heads of the combiner pins, *i.e.*, the tension on the head of the lever B^1 is communicated to the combiner pins in the direction left to right as indicated by the arrow (figs 31 and 34.) The spring S thus keeps the heads H^1 (figs 27 and 34) of all the combiner pins together as a compact mass so that any dipping motion of the feet of the combiner pins is communicated through the heads to the propelling lever L, resulting in a downward impulse at the free end of the latter.

The combiner pins also receive another impulse, when their feet rise out of the indentations, which is augmented by the speed at which the combiner wheel is revolving ; the propelling lever L therefore again takes part in this second impulse and its free end takes an upward direction. It is this second impulse which is utilised to operate the unlocking of the printing arm ; the first impulse merely increasing the striking distance of the *pedal* lever which will be presently described.

84. A small cylindrical attachment R^1 (fig. 35) is fixed to the free end of the lever L by means of a shoulder screw. Into R^1, which is provided with a female screw, a rod R is fitted ; the other end of R terminates in another cylindrical attachment R^2 similar in shape to R^1; the rod R with these two attachment R^1, R^2 is termed the *propelling rod.* Care must be taken not to confound the *propelling rod* with the *propelling lever.*

The lower end of the propelling rod is similarly connected by a shoulder screw to what is termed the *pedal lever* L^2. This lever is pivotted at the centre; and at the extremity away from R^2, it is provided with a striking head, which acts on one end of a *locking lever* L^3. The lever L^3 is pivotted near its centre and its free end is provided with a hooked tooth T (fig. 35.)

85. Returning to the action of the propelling lever L (figs. 34 and 35) its two impulses downwards and upwards, are imparted through the propelling rod R to the pedal lever L^2. The first, downward, impulse results in the striking head of the pedal lever L^2 being raised away from the adjacent end of the locking lever L^3, and thus the striking distance is increased; the second, upward, impulse of the propelling lever L and of the propelling rod R results in a lowering of the striking head of the pedal lever L^2, and consequently by striking the adjacent end of the lever L^3, in raising the toothed end of the latter which unlocks the printing arm. A small screw S inserted in a cock on the front plate of the Receiver regulates the position of the locking lever L^3 and the degree of depression of its toothed end T. A flat spring S^1 below the lever L^3 supplies the necessary pressure to keep it against the screw S and to maintain its toothed end depressed so as to lock the printing arm when it is not operated by the pedal lever L^2.

86. The means adopted to replace the printing arm will be described later; having however, seen how the electrical impulses imparted to the electro-magnets are converted into mechanical impulses which produce the unlocking of the printing arm, the process of printing may now be considered. In every printing process the principal parts requiring attention are those employed for adjusting the paper to be printed on, the type which prints, and the means adopted to impress the type on the paper. In the Baudot printing telegraphs the paper is in the form of tape and the manner in which the printing is effected will be made plain by a description of the parts producing the printing and the propulsion of the paper tape.

87. The printing arm which is shown in figs. 36, 37 and 37 A is constructed as follows:—

Over an axle A (fig. 37) a cylinder O carrying an arm I is fitted, a second cylinder O^1 fitted with a ratchet wheel W slips over O; a third cylinder O^2 fits tightly over O^1. The three cylinders are thus fitted and work on the common axle A. The combined appearance of the three cylinders is shown in fig. 37 A. The cylinder O^2 is cut with rasp-like embossments at both ends and is termed the *paper guide cylinder*.

To the arm I is fixed by means of three screws, a triangular piece of steel M termed the *impression cam*. This cam is provided with a small projection P^1, which engages with the tooth the impression arm is released by the locking lever, the ridge P^2 of this cam M (figs. 37 and 37A.) engages with the notches of the impression wheel and the impression arm is thus carried forward from right to left with the impression wheel in its rotary motion. When the arm is so carried to the left the impression roller is pressed against the type. The release of the impression arm thus results in the paper tape which passes around the impression roller R^4 being pressed against the typewheel and the letter is imprinted. The letter impressed depends on the point at which, in any one revolution of the typewheel, the impression arm is released.

90. The impression wheel W(fig. 39, 40 and 41) fits loosely on the axle A and behind it a *clutch* C^3 is fixed to A by means of a clamping screw C^5 (fig. 40). A strong curved spring C^4 called the *clutch spring* is screwed on to the back of the impression wheel W, and is provided with a tooth which engages with a notch N^1 at the free end of the clutch C^3. By means of the clutch and spring the impression wheel is secured to the axle A and rotates with it. The position of the clutch on the axle is fixed by the clamping screw.

91. A roller R (fig. 40) turning freely on its axis is fitted to the impression wheel and on the plate P (figs. 35, 36 and 38) a lever L^4, called the *replacing lever*, is pivotted at its centre. At each revolution of the impression wheel, the roller R (fig. 40) strikes the upper end of the lever L^4 whilst its lower end is at the same time sent briskly against the part M^1 (fig. 37A) of the impression cam. The roller can thus put the impression arm back, to be held by the locking lever L^3, after each release. As this release can be effected once in each revolution so as to print a letter on the tape, the impression arm at each revolution is re-locked, after the printing is completed, ready to be again released for the next letter.

The locking lever L^2, the impression arm I, and the compression cylinder O^3 are fitted on the small plate P (figs. 35 and 36) The replacing lever L^4 is fitted over a circular disc of brass B (fig. 35) which is fixed by means of three screws to the plate P; the three screws pass loosely through the disc B, the two upper screws passing through holes which are larger than the screws. A pin fixed to the back of the disc B fits into a hole of larger diameter in the plate P. A long screw S^3 enters through the side of the plate P and works against this pin. By means of the screw, S^3, the position of the brass disc B and, through it of the replacing lever L^4 can be adjusted in relation to the part M^1 (fig. 37A) of the impression cam, *i.e.*, it can be placed nearer to or further away from the impression arm, and so regulate the force with which the stroke is communited by the roller R(fig. 40) to the impression arm.

92. It was seen in studying the Baudot Code (fig. 1) that each combination of impulses represents a letter as well as a sign, it needs to be seen how the mechanical change is effected so as to produce

the desired printing. Whenever the figure or letter space is operated, the combiner pins are placed in the back and forward grooves P^5 and P^6, respectively, and the unlocking of the impression arm is effected ; but when the point P^2 (fig. 37A) of the impression cam M enters the notch on the impression wheel, the impression roller R^4 is presented to a blank section of the typewheel and hence, though all the operations described above are performed, no printing is done ; the paper guide cylinder merely moving the tape forward one letter space. There are two distinct positions on the typewheel for the *two space* signals, and these are two blank spaces, which lie between the types on the typewheel. One of these is greater in length than the other: the larger space corresponds to the parts of the combiner wheel occupied by the shuttle S^2 and the replacing cam K^3 (fig. 28) and to the space occupied by the first four indentations on the plates P^5, P^6 (fig. 32). For each of the space signals, the impression cam engages the impression wheel, and in so doing produces a change in the position of the typewheel relative to the impression wheel, a change that places the typewheel so that all subsequent signals produce the printing of letters or of figures and signs according to whichever space signal has been transmitted, *e.g.*, if letters were being impressed, a change over to figures could be effected by pressing the fourth key only. The result obtained is a turning of the typewheel one letter space either to the left or right, so that the impression roller is brought against the types adjacent to those presented to it previous to the use of the space signal. The repeated use of the same *space* signal produces no change in the position of the typewheel after the first change has been effected. To fulfil all the above requirements the typewheel has the types arranged around its periphery, letters and figures or signs alternately.

How this change is effected will now be seen, and in describing this it will also be seen how the typewheel and impression wheel are secured to each other and work together.

93. Fitted on the face of the impression wheel are two crank levers P and P^1 (fig. 39), termed the *inversion plates.* A lever L^1 termed the *inversion lever* with three arms a, b, and c is fitted to the cylinder C^2 (fig. 40) to which it was mentioned the type wheel was fixed by the three screws S S^1 and S^2 (fig 25). The two arms b and c of the inversion lever (fig. 39) fit into recesses in the inversion plates P and P^1. The third arm a which is much longer than b and c is terminated in a sharp edge against which the rounded end of a *pawl* L impinges. The pawl L is pivotted at one end of a small bracket B fitted on the impression wheel a spiral spring S winds round the axle A^1 of the pawl L, and causes its free end to press firmly on one side or other of the edge E of the arm a, somewhat after the manner of a jockey roller. The arms of the inversion plates, P and P^1, adjacent to the inversion lever

engage the lever arms b and c, whilst the free ends F and F^1 of P and P^1, which are rounded off, border on the periphery of the impression wheel in such a manner that either one or the other covers the notch adjacent to it, as seen at N, according to the position of the pawl L, relative to the arm a (fig. 39). It may be here mentioned that the replacing roller R (fig. 40) is fitted directly opposite the screw fixing the inversion plate P^1.

When the point P^2 of the impression cam M (figs. 37 and 37A) engages with the notch covered by the inversion plate, in entering the notch, the end of the arm I adjacent to P^2 (fig. 37A) presses the inversion plate inwards resulting in the end E of the arm, a, (fig 39) passing over to the opposite side of the pawl L as indicated by the dotted lines, thus slightly altering the position of the type wheel, which is fitted rigidly to the inversion lever, relative to the impression wheel. When the impression arm(fig. 37A) is released the impression cam M first engages a little with the notch covered either by F or F^1 (fig. 39), and the force necessary to push either the plate P or P^1 and effect the change-over action is obtained from the rotary motion of the impression wheel, the momentum of which is sufficient to effect this. The inversion plate P^1 (fig. 39) corresponds to the *letter* change and the plate P to the *figure* change, the plates are so fitted that when one end F is pushed inwards by the impression arm the other end F^1 is simultaneously brought out and thus set ready for the change over action of the arm a to the opposite side of the pawl lever L.

94. The *inking wheel* W^2 (fig. 38) is fitted above the typewheel. A spiral spring S^4 provided on the supporting arm supplies the force required to keep the wheel W^2 against the typewheel, the further adjustment of the inking wheel in respect to the typewheel is regulated by means of a projecting pin on which the arm of the inking wheel rests. The pin is attached by means of a small brass plate screwed to the front plate of the Receiver and by lowering or raising it, the inking wheel is allowed to exert more or less pressure on the typewheel. On the circumference of the inking wheel W^2 is a groove in which is inserted a felt band to absorb and supply the ink.

95. To the right of the front plate of the Receiver the tape reel R (fig. 38) is fixed on a brass arm A^3. From the reel R the tape is led to a guide rod G, between it and a flat spring, thence round guide rod G^1 (figs. 38) the pin P^2, (figs 36) the printing roller R^4 between the paper guide cylinder O^2 and the compression roller O^3, and out into a trough G^2. One end of the trough G^2 is bent upwards and lying directly beneath the compression cylinder O^3 picks up the tape. A cross-piece H is fitted over G^2 to keep the tape in place.

96. Before proceeding with a consideration of the various faults and their remedies it will be well to clearly understand what

will already have been gathered from Chapter II. An extra signifies an impulse too many, and a failure, an impulse too little. Inasmuch as the Baudot Code consists of combinations of five impulses, the positive ones being active, a failure would mean either that one of the five electro-magnets has failed to respond or that the letter printed is what would have resulted had the armature of the electro-magnet and connected mechanism failed to respond. For example, the printing of the letter U for T would be due to a failure of the fifth and similarly an F for a G would be due to an extra third. These defects in the Receiver may be caused by an imperfect action of the armatures or by incorrect adjustment of the mechanical parts.

97 *Faults in the Receiver* Failures may be brought about by a variety of causes, some of which are frequently due to faults of adjustment.

(*a*) As already explained the rest force for the appendices is supplied by the antagonistic spring F (fig. 28). The force of this spring should be just sufficient to put the armature back to the rest position.

If the upward tension of spring F is too great, the result will be a failure of the armature to be attracted sufficiently so as to bring the appendix smartly on the appendix lever, which latter will not in consequence actuate the corresponding combiner pin, the foot of which will not be put into the forward groove. As a general rule, only one prong of the spring F (fig. 28) should be sufficient to give the desired rest force, and the second prong should be allowed to remain flat against the lower surface of the armature.

(*b*) A weak propelling spring S fig. 34) will result in irregular pressure of the propelling lever L on the heads of the combiner pins. In consequence, the feet of the pins will fail to dip forcibly into the indentation and letters will not be printed, due to no impulse being transmitted by the propelling lever L to the propelling rod R, and its connected mechanism. This fault will result in continued locking of the impression arm and signals indicated on the electro-magnets will not be printed on the tape. It may be noted that a weak propelling spring sometimes produces only occasional failures. Too much pressure of the spring must be avoided, as it will cause the feet of the combiner pins to wear down on account of the friction introduced. The fixity of the propelling lever L (fig 35) should also be noted, as the pin fixing the lever to the axle may run loose and give rise to irregular printing.

(*c*) Failure of entire letters may be due to the replacing lever L^4 (figs. 25 35 and 38) not functioning correctly. As already mentioned the replacing roller strikes the upper end of L^4, the lower end of which pushes the impression arm I (fig. 36) so as to re-lock it with the locking lever L^2. If therefore the action of the replacing lever is incomplete, the lever L^2 (fig. 35) will fail to engage the impression arm. This is remedied by screwing in the adjustable screw S^3 (fig. 35). The best method is to completely unscrew S^3 and move the piece B to its extreme left position; then transmit the letter T from the corresponding keyboard and screw in S^3 till a continuous string of the letter T is obtained on the tape. When this adjustment has been made the stroke of the replacing lever L^4 on the impression arm I can be felt even after it is locked by the lever L^2.

(*d*) Inefficient attraction of the armatures with attendant failures will result from faulty adjustment of the armatures and appendices. When a Receiver is first brought into use or when a new appendix is fitted, the bent edge of it should be about a third of an inch from the horizontal arm of the appendix lever the edge being filed down to suit. The distance of the armature from the poles should be about an eighth of an inch; and with the armature depressed there should be no play between the appendix and the appendix lever, the vertical arm V (fig. 28) of which should not touch the ring R of the combiner wheel. The latter point is a test of the correct adjustment of the former; the amature being pressed on to the pole-piece, the appendix in coming against the appendix lever, should not bend; a small play between the appendix and the appendix lever may be permitted so as to obviate the bending of the appendix and prevent the appendix lever pressing against the ring R of the combiner wheel. In practice, all adjustments are effected by means of the notched screw N (fig. 28).

(*e*) The appendix lever spring F^1 (fig. 28) should not press too heavily on the levers. The adjustment of the pressure is obtained by means of the two screws securing the block K^2 to the brass plate B^2 (fig. 28). In effecting this adjustment care should be taken to loosen one screw before tightening the other. The spring F^1 can also be raised and lowered slightly, and in this way the position of the appendix may be regulated in regard to its distance from the combiner wheel. The correct position once obtained seldom needs readjustment; all minor adjustments being effected by means of the notched screw N (fig. 28).

98. Some causes which produce extra signals may now be considered. As a general rule, all moving parts must, to avoid extras return freely to their normal positions.

(*a*) Extras are caused by the spring F (fig. 28) being too weak, with the result that the armature is not put back to the rest position, and the appendix may continue to depress the appendix lever. When this occurs the second prong of F may be brought into action, but this is seldom necessary.

(*b*) A heavy pressure of the propelling spring S (figs. 34 and 35) some times causes friction between the heads of the combiner pins, and in consequence the operation of any one of the pins tends to draw the adjoining pin along with it thus producing extras. The tension of the propelling spring being normal the friction between the heads should be almost eliminated by making the rubbing sides smooth and by proper oiling; this fault is generally characterised by a particular pin only being affected thus for example an extra third is occasionally caused when the second and fourth combiner pins or either of these two are operated.

(*c*) Extras may also be caused by a wearing of the lower end V of the appendix lever adjacent to the guard plate (fig. 28) the wear results in the appendix lever failing to engage with the appendix lever spring F^1 after it is ejected by the shuttle. The re-adjustment of the spring F^1 will remove this fault.

(*d*) A weak tension of the appendix lever spring F^1 gives rise to a *similar* fault, the tension not being sufficient to engage the lever.

(*e*) Extras are also caused by irregularities in the feet of the combiner pins. The feet should all be of equal length; if any one of them is shorter than the other it will be unfirm and shaky. A grinding wheel is provided for setting these feet; it is of the same diameter as the grooved plates P^5 and P^6 of the combiner wheel (fig. 28). The axles A^2 (fig. 28) of the combiner pins should not, when their feet are in the forward groove, touch the propelling lever.

(*f*) It sometimes occurs that the letter L is printed without the corresponding electro-magnets being operated. This is due to the replacing roller R (fig. 40) knocking against the pedal lever L^2 (fig. 35) during each revolution. The adjustment of the lever L^2 is obtained by regulating the propelling rod R (fig. 35) to the correct length. To regulate the length of R detach the attachment R^1 from the propelling lever L and screw R^1 in or out of the rod to respectively shorten or lengthen the rod. In effecting this adjustment, the position of pedal lever L^2 relative to the locking lever L^3 needs attention, there should be a distance between the two such as to permit the free passage of a piece of paper tape.

(*g*) An extra R similarly results from the roller R (fig. 40) striking the spring S^1 (fig. 35) of the locking lever L^3. The position of the locking lever can be adjusted to obviate this fault. Its tooth T should go a little beyond the projection P, at the back of the impression arm, with which it engages. The small screw C^1 regulates this. The edge of the tooth and of the projection should both be sharp otherwise faulty locking of the impression arm will result. Care should also be taken that there is no knocking against the screw S.

99. It may frequently occur that the impression wheel gets unlocked from the clutch C^3 which fixes it to the axle A (fig. 39). This may be due to the impression cam M (figs. 37 and 37A) being loose on the impression arm I, or to its edge being blunted and so not gearing properly with the notches of the impression wheel; the three screws fixing M to the arm (fig. 37) should be tightened, and if necessary the edge of the impression cam should be ground sharp.

Another cause, for the unlocking, is an incorrect position of the impression wheel on the axle; readjustment by means of the clutch C^3 will remedy this defect which is due to the cam M not gearing properly in the notches of the impression wheel W.

The adjustment of the position of the impression wheel should be effected as follows:—Depress the armature of the first or extreme left electromagnet turn the combiner wheel gradually and send the first combiner pin from the back to the forward groove; let the foot of this pin, which can be seen through the aperture (fig. 35) in the front frame plate, just rise out of the indentation on the combiner wheel into which it dips, unscrew the clutch C^3 and turn the impression wheel which carries the clutch along with it, till the impression cam M on the impression arm I, being released, rests on the middle of the raised edge preceding the first notch of the impression wheel corresponding to the letter A. Tighten the clutch screw thus fixing the clutch firmly on the axle.

Another method of obtaining this adjustment is to depress the armature of the second electro-magnet and produce the displacement of the second combiner pin. The combiner wheel should be turned till the foot of this pin falls into the indentation of the forward groove. When the five feet of the combiner pins find their respective indentations in the back and forward groove, the fall of the feet will be felt in turning the combiner wheel. The foot of the second pin can also be seen through the aperture in the frame plate to be at the bottom of the indentation in the forward groove. In this position the clutch C^3 being loosened, the impression wheel should be turned till the edge P^2 of the cam M is exactly opposite to the first notch of the impression wheel which corresponds to the letter A; the impression arm I in this case should not be released from the locking lever.

If the pawl lever L (fig. 39) presses too hard against the arm A, of the inversion lever considerable force will be required to move the arm a from one side to the other of the pawl and the result will be unlocking of the impression wheel. The unlocking in this case takes place when the inversion is performed, *i.e.*, by the depression of either the fourth or fifth armatures.

100. On the other hand, too light a pressure of the pawl L on the arm A of the inversion lever will result in failures, of the inversion of the typewheel. The correct position of the pawl is that where, when the sharp edge of the lever L and that of the arm, a, are opposite each other, the arm, a, is exactly midway between the limiting screws (fig. 40) on either side of it. The edge of the pawl should not be too sharp, but a little rounded so as to permit of the inversion arm, a, passing easily from one side to the other.

101. Faults of progression, *i.e*, the driving forward of the paper tape, are chiefly due to defective action of the clicks F and F^1 (figs. 33 and 35) on the ratchet wheel. The upper click F should be so fitted that its free end does not act against the rise of the tooth of the ratchet wheel next to it. If there is no space between these two, or if there is very little space the click will not fall over the edge of the succeeding tooth. Care should therefore be taken that the click falls over each tooth properly and so sends the ratchet wheel W (figs. 33 and 36) and cylinder O^2 forward a tooth space each time; failure in this action will result in *letters being printed over each other*. If the space between the end of the click F and the tooth of the ratchet wheel W be too great the paper will bulge, because the forward movement of the paper will not commence till a certain portion of the movement of the impression arm I takes place, and the result will be a *blotch between letters* due to the bulged portion touching the typewheel. Bad or irregular progression results from wearing of the ends of the two clicks F and F^1 and *blotches between letters* occur; when this happens the clicks should be renewed. The screw and washer S^1 (figs. 37 and 37A) if too tight over the paper guide cylinder will prevent the moving forward of the paper type by obstructing the free action of the paper guide cylinder, and *letters will be printed one over the other.*

Another cause of this fault is a weak spring on the lower click F^1 the click will not, in such a case, engage with the ratchet wheel and, therefore, cannot prevent the paper guide cylinder from rolling back when the impression arm is replaced. The click F^1 should press well against the teeth of the ratchet wheel W (fig. 36) and no space should exist between the two; otherwise irregular progression will result. F^1 is sometimes prevented from acting properly on account of the pressure of the compression cylinder O^3 (fig. 36) being too great. A faulty progression of the tape will occur if this compression cylinder is worn, in which case it ought to be turned on a lathe. Paper fluff should be carefully removed from the axles, clicks, etc., or the progression of the tape will be affected. In all cases of faulty progression the *space between letters* will be irregular.

Occasionally the bent end of the guide trough G^2 (figs. 25 and 38) catches the paper and puckers it; the edge of the trough should be clear of the tape, where it leaves the compression and paper guide cylinders O^2 and O^3 (figs. 36 and 38).

102. A point of very great importance is a good impression, as on it depends the commercial value of the entire Baudot system. Besides faults of progression, bad impressions result from faulty impression pads, R^4 (fig. 36) bad position of inking wheel W^2 (figs. 25 and 38), and defective adjustment of the inversion lever, and typewheel.

103. The correct position of the pawl L (fig. 39) in relation to the inversion lever has already been explained, but it may occur that with this adjustment of pawl and inversion lever the space between the arm a and the limiting screws (fig. 39) may not be absolutely equal. The attendant result is that either *figures only* will be printed heavier on the left than on the right, or that *letters only* will be heavier on the right than on the left. In the former case there is too much space between the arm a and the left limiting screw, and in the latter case between the right limiting screw and the arm a. The limiting screws should be either interchanged or new screws put in. In exceptional cases where there is much wear of the arm a it may be necessary to put in a screw with a very slightly larger head.

104. When *both letters and figures* are printed heavier on one side than on the other the typewheel should be readjusted by means of the screws S S^1 and S^2 (fig. 25), but before trying this, the fixity of the impression cam M should be attended to, as frequently a loose cam will produce heavier printing on the right than on the left.

105. The adjustment of the typewheel is effected by the trial and error method.

An useful help in adjusting the typewheel is to get either the top edge of the letter A or the figure 1, dependent on the position of the typewheel relative to this impression wheel, to be in line with the apex of the notch in the impression wheel corresponding to the above letter and figure respectively. This is only an approximate adjustment and the correct position must be obtained experimentally so as to get an uniform print.

CHAPTER VI.

DISTRIBUTOR PLATES AND BRUSHES.

111. In Chapter I *the plates* of the distributor, as they are technically called, have been shewn as sections of rings. A description of these plates as used on a double terminal set will now be given. The translation plates which differ only in arrangement will be considered separately in Chapter IX.

112. The *double plates*, as used in India, consist of three complete concentric rings of bronze VI, V and IV (fig 42) and three divided rings III, II and I, each of increasing diameter fitted concentrically around the first three.

113. Rings III, II and I contain 14, 14 and 12 segments respectively. The first or outermost ring is arranged in three moveable arms consisting of sets of segments, the first of five numbered 1 to 5, the second of six numbered 6 to 11, and the third of a single segment numbered 12 (fig. 42) and called the *moveable contact ;* segments 1 to 5 and 6 to 11 being termed the *moveable arms*. For purposes of convenient reference the first moveable arm, segments 1 to 5, is called the *first arm*, and the second moveable arm, segments 6 to 11, the *second arm*.

114 The segments of ring I are mounted on moveable bases of ebonite which are arcs of the outermost ring. These arcs E are fixed between two circular brass bands or collars C and C¹ which are provided with ledges L and L¹ (fig. 43). These ledges fit into suitable slots cut into the ebonite arcs E in a manner such that they can be moved when required either clockwise or counter-clockwise within a range of at least 60 degrees either way. The moveable contact (fig. 42) and each of the moveable arms of ring I are mounted on separate ebonite arcs and can be moved independently of one another. The brass collars C and C¹ (fig. 43) are provided with foot-plates F and F¹, which overlap each other and are secured together by means of the screws S¹. The ebonite arcs are thus kept in position between the two collars and the surfaces of the segments are maintained always in the same plane. Segments 3 and 9 of the moveable arms, and the moveable contact are provided with handles H (fig. 41) by means of which they can be moved as required for purposes of adjustment.

Each of the segments S of ring I is secured to its ebonite arc by a screw S¹ (fig. 43) which passes through the ebonite and is provided with steady blocks which fit into suitable grooves in the ebonite to keep the segments from moving laterally. The head of each screw S^1 is screw-tapped to receive a second smaller screw S^2 which secures the connecting wire to the segments. A circular cup-shaped washer receives the end of the connecting wire which is formed into an eye. A slit on the side of the cup-washer admits of the wire passing out of the cup.

Small springs S^3 are fitted in holes in the ebonite arcs and pressing against the collar C (fig. 44) keep the arcs firm in position.

115. The segments of rings II and III are similarly fitted each by separate screws S^5, S^6, to a fixed circular block of ebonite E^1 which is secured tightly within the inner collar C (figs 42 and 43) by means of screws S^7 which pass through the ledge L of the collar (fig. 43).

Rings IV, V and VI being complete rings are fitted each by a few screws to the block E^1 and the wire connected to each of these rings is joined as explained in para. 114. The collar C^1 is divided into two semi-circles.

The leading wires connected to the segments of ring I pass through three small apertures in the inner collar C, sufficient slack being allowed to permit a free movement of the moveable arms and moveable contact within the circle contained by the two collars C and C^1. All the wires leading from the segments and rings of the distributors are tied together into a cable and pass out through suitable apertures in the two collars, provided at the junction of the two semi-circles forming the collar C^1. These wires are led to a terminal board called the *test box*, which will be described in Chapter VIII.

116. Both the back and front frame plates of the distributor are provided with a circular groove into which the heel H at the foot of the collar C (fig. 43) fits. The collars C and C^2 and all that is contained within them are secured, in a double terminal set, to the front frame plate by means of two brass keepers K and K^1 (fig 42) which fit into a slot S^8 (fig 43) formed at the junction of the foot-plates of the collars, and which are fixed to the frame plate by two screws S^9 and S^{10} (fig. 42). On the keeper K^1 one of the screws is provided with a handle H^2 to tighten the collars when the plates are shifted *en masse* as will be seen when the subject of translation is dealt with.

117. The segments of rings I, II, and III are insulated from each other and are made narrower at the base than at the top.

A circular aperture is cut in the centre of the ebonite block E^1 (fig. 42) through which the main axle A (fig. 43) of the distributor, which carries the brush arms, passes.

118. It was mentioned in para. 9, Chapter I, that a signal was formed by the transmission of five impulses, positive and negative, through a line which is applied successively to five points. Five segments are therefore required for transmitting and five for receiving

the impulses. We have seen that in ring II there are 14 segments. Ten of these are employed for transmitting and receiving the impulses and two for the maintenance of synchronism.

The subject of synchronism will be treated separately in Chapter VII, but for the present let it be assumed that the synchronising or correcting currents are being sent through the last two segments of ring II. There are still two segments, *viz.*, Nos. 11 and 12 spare. These are provided to overcome the effects of retardation.

119. It is well known that an electrical impulse emitted at one end of a telegraph line takes a certain interval of time to make itself felt at the distant end. This interval, however small, is not negligible in high speed telegraphy, and is dependent on the self-inductance and capacity of the circuit. On the longest direct worked circuits in India it is about one-fortieth of a second.

It was mentioned in para. 12 that the transmitted and received impulses are not simultaneous *i. e.*, a station, say A, which receives on the first arm (segments 1 to 5) does not start transmitting until the last impulse sent through the fifth segment of ring II by station B reaches it. If the time between emission at one station and arrival at the other is equal to, say, one eighty-fourth of a second, it is evident that the brushes at station B will have travelled over half of segment 6, ring II, before the impulse transmitted on 5 is completely received at A, and further when A transmits on segment 6, the signal will not arrive at B till after the lapse of one eighty-fourth of a second during which interval B's brush will have passed completely over segment 6 and be entering on segment 7. B therefore neither sends nor receives on segment 6. It is evident from the foregoing that when the interval of retardation in any circuit is equal to one eighty-fourth of a second a whole segment is lost between transmission and reception at the correcting station (segment 6) and between transmission and correction (segment 11) at the corrected station (*vide* fig. 45).

Similarly if the retardation is equal to one forty-second of a second, two whole segments will be lost, *i. e.*, there will be two segments at each station on which impulses will neither be sent nor received. Adding these two segments to the 12 employed in transmitting, receiving and correcting, we have a total of 14 segments on ring II.

In practice, the arriving impulses may not coincide exactly with the segments as shown in fig. 45, but may overlap sections of two segments as shown in fig. 45 A.

120. In para. 12, Chapter I, the definition of the terms *corrected* and *correcting* stations was given. It will be well to add that the correcting station invariably sends on segments 1 to 5 of ring II, corresponding to the first arm, the working currents being preceded by the correcting impulses, positive and negative, either from seg-

ments 12 and 13 or 13 and 14. The general practice adopted in India is to emit these correcting currents from segments 13 and 14.

Since at the corrected station the reception follows correction, it is obvious that retardation affects similarly the correcting and the working currents. The time interval between the emission of these currents at the correcting station and their arrival at the corrected end will be equal. It follows, therefore, that at the corrected station the effects of retardation are *practically* nullified, as far as the working segments of the corrected distributor are concerned; the retardation segments being placed between the last segment of transmission and segments of correction. On the other hand the correcting station has its segments of retardation between the segments of transmission and reception, hence it is that a corrected station is more favorably situated in its reception of signals than a correcting station.

121. In referring to the interval of retardation it is found convenient to express the delay in the arrival of an impulse in terms of the distance the brushes will have travelled during the interval; thus if an impulse takes one eighty-fourth of a second before it reaches the distant end, the retardation is spoken of as equivalent to half a segment because the brushes on ring II will have passed over just half a segment in that period of time, it being remembered that the rate of revolution is 180 per minute.

If then the retardation of a circuit is equal to half a segment, it is evident that for the received signals to fall on a particular segment the brushes at the corrected end must be kept rotating half a segment behind those at the sending or correcting end. For example, say correcting station A, is sending its first impulse on segment 1, just as its brushes are in the middle of segment 1, the brushes of corrected station B, which is receiving, should be entering on segment 1, *i.e.*, exactly half a segment behind station A, the difference in each case being equivalent to the retardation of the circuit. When the fifth impulse from station A is completely received at B the brush of ring II at A will be in the middle of segment 6 and the first impulse from B transmitted on segment 6 will not be felt at A till its brush is entering on segment 7, *i. e.*, the brush at B will be on the middle of segment 6 just as A is entering on 7 in which case the brush at A is still half a segment in advance of B. The synchronism therefore between the brushes at stations A and B, is such that an allowance has to be made so that the brush at A being at a certain point on ring II when it commences to transmit, the brush at B will be at a similar point on ring II, when it commences to receive. The two stations with this consideration may be said to be truly synchronised from an electrical point of view. Hence it was that in para. 10, Chapter I, Baudot synchronism was spoken of as approximate.

troughs. If these adjustments have been carefully attended to the following result should be attained. With the brush of ring II at the beginning of the first segment of ring II, the brush of ring I should be about a third of a segment in front of segment 1 of ring I. Whilst verifying this position the brush of ring III should be either advanced or drawn back in the brush-holder so as to be also at the beginning of the first segment of that ring. The position of the first segments of rings II and III are decided on before the connecting wires are put on and the plates when they leave the factory are marked with a dot on the first segment of each ring.

The click C fixing the brush arms should always engage properly in its notch, and the brush-arms should have no lateral motion. The brush-arms rotate counter-clockwise.

131. It is apparent that the main points for adjustment are connected with the brushes which constitute the weakest portion of the installation. The brushes should protrude from the trough T about a third of an inch. Excessive projection will cause a spreading out of the bristles which will extend laterally on to the adjoining rings. It is necessary besides that the requisite pressure of the brushes against the distributor plates is maintained. The pressure is regulated by turning the brush-holder in its collar so as to put the brush with more or less pressure on the rings, the clamping screws S^1 (figs. 46 and 53) being loosened for the purpose. The pressure should not be too great, but just sufficient to make good electrical contact. Heavy pressure will result in undue friction affecting the speed and hence the synchronism, besides the friction increases or decreases as the brush of ring I is either on or off the segments of that ring. Further, when the pressure of the brush of ring I is too much the bristles will ultimately break away, due to their striking the edge of each segment of that ring. General heavy pressure, in affecting the speed, will result in bad correction and will cause the wearing down of the brushes and plates. In performing the adjustment regulating the pressure of the brushes on the plates, each pair of brushes should be made to take the distributor plates at the same angle and the brushes of each pair should protrude the same length from the trough T.

The tips of all the brushes should be uniform, *i.e.*, all the bristles should be of the same length. This is very important, for besides causing sparking on rings I, II and III, unequal bristles produce bad contact on all rings resulting in failures of the synchronising and working impulses. When necessary the tips of the brushes should be trimmed with a pair of scissors.

132. The following points require frequent attention :—

a. The distributor plates should be clean and free from oil or dirt.

b. The extent to which the brushes project from the trough T should be about a third of an inch, *c.* The pressure of the brushes should be just sufficient to make good contact and should be as light as possible.

d. The tips of the brushes should be clean and uniform.

e. The click should gear well into the notch.

f. The brushes should be placed correctly in relation to each other and to the segments of rings I II and III.

g The spaces between the rings and segments should be free from dust and foreign matter.

133. It will be seen that the above practically summarises all that has been mentioned before, and its importance cannot be too much impressed on the practical telegraphist The first points to be attended to in case of trouble should be the distributor plates and the brushes, as these may truly be said to be the heart of the installation

CHAPTER VII.

SYNCHRONISM. THE DISTRIBUTOR.

134. As has been stated in para. 62 the speed of the last spindle No. 6 (fig. 24) of the distributor driving gear makes 1,260 revolutions per minute, and this speed when communicated through the wheels W and W^1 (fig. 54) to the brush spindle imparts to it a speed of 180 revolutions a minute. This standard speed of 180 revolutions a minute has to be maintained constant and for this purpose a centrifugal governor is employed.

135. To keep the brush arms at both stations in synchronism, the regulator at one station is adjusted to keep the brushes revolving at a slightly enhanced speed, *viz.*, from 181 to 182 turns per minute, and a checking or correcting device is operated at that station by electric impulses from the other.

136. *Principle of the Regulator.*—If we tie a stone to the end of a string and keep rotating it by the hand, it is apparent that if the string is released the stone will fly away at a tangent to the circle described by it. As long as the string is not released, the hand and the string obviously counterbalance the tendency to fly away and keep the stone going round in a circle ; in other words, the hand exerts a certain amount of force in keeping the stone in its circular motion. If the connecting string is replaced by an elastic cord it will be found that with an increase of force there will be an increase in amplitude, *i.e.*, the stone will rotate further away from the centre of rotation the more rapidly it is rotated. The following well-known laws in mechanics may be here briefly given :—

(*a*) The centrifugal force of a body is dependent on its mass, the speed of rotation, and the radius of revolution.

(*b*) When the centrifugal force is equal to the rotary force (force producing the rotation), uniform motion is obtained.

The following corrollaries may be added.

When an elastic medium connects the weight (rotating body) to the centre of rotation it will be found that :—

(*a*) If the rotary force is increased, either the speed of the rotating body or its amplitude, *i.e.*, the circle described by it will, be increased.

(*b*) If the weight of the rotating body is increased, the driving or rotary force remaining the same, its amplitude will be increased and its speed of rota-

(*c*) If the rotary force is decreased, the amplitude of the rotating body must also decrease, otherwise its speed will be decreased.

(*d*) The greater the amplitude of the rotating body, the greater the damping effect on the rotary force, the speed being the same.

The rotary force being varied, if the centrifugal force can also be varied, by automatically altering any one of the three factors on which it is dependent, it will be possible to obtain uniform motion or speed. Thus if friction in the clockwork absorbs a certain amount of the driving force, the rotating body may still be maintained at the same speed if its amplitude could be automatically reduced. The Baudot governor is constructed on the above principle, *i.e.*, the speed of rotation is controlled by an automatic variation of the radius of the rotating body.

137. The *governor* consist of a brass sleeve or tube T carrying two arms A; (fig. 55) the tube T which is cut with a slit S over a portion of its length fits on to the governor spindle and is secured to it by means of a clamping screw S¹ passing through a split collar C which forms part of the tube T.

Behind the sleeve is fitted a second split collar fixed by a jamming screw, which serves to maintain balance on the opposite side of the spindle. For this purpose it is provided with an engraved line which in fitting on the governor is made to coincide with the slit of the sleeve T. The tube and arms are thus secured firmly to the sixth or governor spindle of the driving gear.

Two highly polished steel guide rods R pass through the arms A (fig. 56) and are firmly secured to the latter by means of two clamping screws C and C¹. On both sides of each of the rods R worms are cut. Two nuts N, N screw on one side to these worms and over these is fitted a metal bar M (fig. 57) called the *adjusting bar*, provided with two holes H through which the rods pass. Above this bar two more nuts N¹, N¹. are screwed and firmly hold the adjusting bar M in position.

Two steel spiral springs are passed through two holes H, H in an octagonal block or *weight* of brass B (figs. 58 and 59) and are secured to the same as follows: the vertical sides V of two L shaped pieces of flat sheet steel are secured to the block B by means of two small screws S², while the horizontal sides enter through slits S³ (fig. 60) in the block and pass through the convolutions of the springs. The springs are thus held in the weight.

Two smaller holes H¹ are provided in B (fig. 58) through which the guide rods R pass. On one side the springs (fig. 59) are terminated in loops L which fit on to two studs S (figs. 56 and 57) provided on the adjusting bar M.

variation is indicative of a good controlling action of the slight variations in the clockwork.

141. It was mentioned that the governor controls the speed by means of the lateral pressure exerted by the governor spindle on its bearing. To maintain this constant, other conditions being normal, the friction has to be kept constant. This is effected by frequent oiling arranged for by means of a syphon, which consists of a bent brass tube through which a few threads of raw cotton are passed. One end dips into a small bottle of oil fixed in a recess on a piece of wood placed on the base plate of the distributor, and the other end enters into the oil vent of the bearing. A small hole at the top of the brass tube prevents too free a flow.

142. It was mentioned in para. 120 that the correcting impulses are sent from the 13th and 14th segments (ring **II**) of the correcting station, these impules are employed to operate an electro-magnet which damps the speed of the brushes. This electo-magnet or electro-corrector is constructed as follows:—

The *electro-corrector* is a non-polarised instrument and consists of two coils C (fig. 61) wound to a resistance of 20 ohms each. The coils are joined in series and mounted on a brass frame F which slides into grooves on brackets B fixed to the frame-plate P of the distributor (fig. 54).

The armature A (fig. 61) is pivotted directly below the coils by means of two small screws passing through the frame at S (fig. 61). Two small extensions of the armature E E lie directly beneath the cores and an adjusting screw S^1 passing through the frame abuts against one of them and regulates the play of the armature. In the centre of the armature a small crank attachment T (fig. 62), fitted to the armature, carries on one side an arm *a* to which a small bent spring S is attached; this spring is split and slips over the head of a *correcting-pin* P which works in a guide hole in a small socket S^1 (fig. 62) attached to the frame F; the object of the spring S is to obviate vibration of the pin when in action. On the upper side of the crank T (fig. 62) is a pin P^2 working in a prong P^3 which forms a continuation of an indicator **I.** This indicator is supported by a bracket *b* attached to the frame F, a small slit on the top of the indicator carries a vane of paper .Whenever the armature is attracted and released the pin P^2, working in the prong as indicated by the arrows, turns the indicator and the vane describes an arc of a circle, thus showing that the electro-corrector is being worked.

Whenever the armature is attracted the correcting pin P is shot forward and when the armature is released a cam, which will be described in due course, sends the pin and armature back to the normal position. The action of the electro-corrector in sending forward the pin P and indicating the same on the vane V is thus far complete, and all that follows is purely mechanical.

143. The spindle to which the distributor governor is fitted, gears with wheel W (fig. 54) which in turn gears with a wheel W^1, fitted free on the axle A which carries the brush arms. A smaller toothed wheel W^2 is rigidly fixed by three screws to W^1 and gears with a pinion p pivotted in a circular disc or block of brass D which is rigidly fixed to the brush arm axle A (figs. 54 and 63). The axle of pinion p passes through the disc D and into it screws the shaft of a second pinion p^1, slightly larger than p: the pinion p^1 gears with a third pinion. A star-wheel S is fixed to this pinion, and is pivotted on the one side in the disc D and on the other in the disc D^1.

A jockey roller R (figs. 54 and 64) carried on a curved steel spring S^1 attached to the block D presses between two teeth of the star-wheel, and the whole of the block is thus secured to wheels W^2 and W^1 by means of the connecting pinions p, and p^1.

144. As long as the jockey roller R is pressing against the star wheel, the wheels W^1 and W^2 carry the block D and connected axle A along with them in their rotary motion, which is thus communicated to the brush arms. If, however, the pressure of the jockey roller is removed from the star-wheel, the pinion p and p^1 take up the rotary motion and communicate it to the star-wheel only.

The block B, being connected by the jockey roller, is thus thrown out of action along with the axle A on which it is fixed, and the brush arms are thrown out of gear. The wheels W^1 and W^2 are thus rendered free whenever the jockey roller is not pressing on the star-wheel. Now each time that the pin P (figs. 61, 62 and 63, para. 142) is shot forward by the attraction of the armature of the electro-corrector, it engages with one of the teeth of the star-wheel (fig. 64), and in doing so has a tendency to stop the whole clockwork, but the momentum of the latter causes the jockey roller to ride over the adjacent tooth of the star-wheel with a slight jerk, and when this happens the star-wheel, being temporarily detached from the roller, turns on its axle and the block D and axle A are thrown out of gear for a very short instant of time. This action takes place every time that the electro-corrector is worked by the synchronising current from the distant station, which under the best conditions should take place once in two revolutions. It must be remembered that the correcting-pin does not act as a brake to the clockwork. The same effect is produced as when a cyclist ceases to pedal on a free wheel machine ; the driving gear is thrown out of action, but the cycle continues to move on account of the momentum acquired ; though in this case with gradually decreasing speed the driving force being removed. The axle of the brush arms at the corrected station is thrown out of gear and its speed is consequently damped once in two or three revolutions, thus bringing it down to that of the correcting station and synchronising the two distributors. The speed of wheel W^1 remains unchanged the driving force not having been removed.

After the correcting pin P engages the star-wheel and throws the axle A out of action, a cam K fitted on the disc D (figs. 63 and 64) replaces it in its normal position, and it is once again ready to be shot out by the armature in the next revolution.

145. The two ends of the coils of the electro-corrector are led to two brass cross-pieces C (fig. 54) fitted directly above them. These cross-pieces are insulated from each other and from the brass frame of the distributor by ebonite washers. Two screws insulated with ebonite bushing pass through the front frame plate P, and are connected one to earth, the other to the movable contact or 12th segment of ring I. The cross-pieces are connected to these screws and through them the electro-corrector terminals are connected to the 12th segment and to earth through the distributor cable.

146. It was mentioned that the correcting station sends correcting positive impulses from the main battery through segment 13 (ring II) once in each revolution. When the corrected station starts turning, these impulses may be received on any one of the 14 segments of ring II. As long as the arriving impulses do not work the electro-corrector, the corrected station brushes will be gaining on those of the correcting station and the impulses will pass from one segment to the other, *e. g.*, say the 1st correcting impulse is received on segment 1, ring II, the brush on ring I will be over the 1st segment of that ring, and the letter A will be printed on the receiver ; this letter will be imprinted two or three times, then É will appear indicating that the impulse is overlapping segments 1 and 2, this will be followed by E and so on, the distributor brushes gaining the whole time. The letters imprinted on the tape will come out in the following order A A A É É É E E E I I I Y Y Y B B B, then a long space follows until the impulse arrives on segment 12 or movable contact on ring I, the movable contact is so placed that the correcting current is received on the right end of the 12th segment, *i.e.*, the impulse is received while the brush is travelling over a sixth of a segment from the extreme right end of the segment. This is done with the object of obtaining as good a correction as possible. The best effect being obtained when the correction is received during every alternate revolution. In speaking of the reception of the incoming currents on ring I, it must be remembered that these segments are placed to correspond to those of ring II on which the actual reception is performed the electro-magnets of the receiver and the electro corrector being worked in a local circuit. It will be seen in the diagram on terminal working that the working contact of the relay is joined to a local battery of 10 volts, and the tongue is joined to the fourth ring of the distributor ; whenever therefore an incoming impulse works the

relay, and the brush of ring I is simultaneously passing over the moveable contact, the circuit of the local battery will be closed through the electro-corrector which is thus worked. A negative impulse from the main battery is sent by the correcting station through segment 14 immediately after the positive from 13, this impulse puts back the relay tongue against the rest contact.

147. The bearings and wheels of the distributor should be oiled frequently. The correcting gear also should be carefully oiled, otherwise faulty synchronism is likely to result. The centre brush axle A is provided with oil vents on the top of the distributor frame-plates. In order to prevent the oil running out under the distributor plates a groove is provided in the bearings of the brush spindle and the oil collects in them lubricating the spindle, a small vent leads out from this groove to the innerside of the frame-plate and any excess of oil is thus allowed to overflow inside the distributor and not under the segment plates.

Wheel W (fig. 54) which gears with the governor spindle of the driving gear is not provided with an oil vent, its bearings should be occasionally oiled otherwise the speed will vary.

148. The jockey roller R on the star-wheel should be adjusted by moving the spring up and down so as to exert more or less pressure on the star-wheel; to do this the fixing screws should first be loosened. The adjustment should be such that when the correcting-pin causes the displacement of the roller, the latter should just ride over the adjacent tooth, and the fall into the adjacent space should be completed by the pressure of the spring. Loss of correction frequently may result from a loose roller or may be due to the pinion p^1 working loose.

149. The correcting-pin should be long enough to engage the star-wheel; when thrust back by the cam it should not be forced in a manner detrimental to the armature *i. e.*, the force applied by the cam should not put the armature with any pressure on to the adjusting screw.

The adjusting screw should be regulated to give the armature sufficient play, and at the same time should not affect the sensibility of the electro-corrector. The length of the correcting-pin and the play of the armature are dependent on each other. The longer the the pin, the larger will be the play of the armature. The head of the pin should have a little play between the spring and the support of the spring: this is effected by bending the spring as required. The pin should work in its socket without any friction. With the correcting parts in good action, the fall of the jockey roller from one space into the other should be audible. Obviously, all faults in the correcting-gear will result in faulty synchronism; attention should therefore be given to the above points.

To obviate ill-effects due to residual magnetism in the cores of the electro-corrector, the direction of the current may be altered by inter-changing the connecting wires.

150. The correcting gear is adjusted so that the correcting-pin is ejected when the rotating disc D has completed about a quarter of a turn after the pin has engaged the star-wheel.

In arriving at this adjustment, the armature of the electro-corrector should be pressed lightly by the finger against the cores and the governor gradually turned around. When the replacing cam K replaces the pin, the finger will be pushed back till after the transit of the cam, when the pressure of the finger will again bring the armature against the cores. In this position of the cam, the brush of the second ring should be at the end of the 12th segment, and the brush of the first ring should be adjusted to pass over a sixth of the moveable contact, the latter being carried to the right. This adjustment may necessitate an alteration in the position of the brush arms relative to the brush axle. This is performed by means of the *adjustable pin collet* R (fig. 48) which regulates the position of the notch into which the clutch of the brush arms fits. The adjustable arm may also require adjustment to suit its position in the first ring.

151. Besides synchronism between the distributors of the two stations, *local* synchronism between the distributor and receivers at each station has to be maintained. As in the case of the distributor, the first point requiring care and attention is the means for regulating the speed at which the type-wheel of the receiver revolves, which, as already mentioned, is kept rotating at a slightly higher rate than the distributor. The regulating device in the receiver is called a *moderator*.

152. The principle of the moderator is the same as that of the governor. The weight W (figs. 65 and 66) is secured by means of two spiral springs S, on a pair of parallel rods R along which it slides. The moderator is mounted on a block of metal B (fig. 66) provided with a hole into which slides the sixth spindle of the receiver driving gear (figs. 24 and 60), a groove is cut in the spindle and a lug L, from a small piece of metal P (fig. 67) inset in the block B, keys into this groove and keeps the moderator from turning on the spindle: a screw S^1 (fig. 68) driven into the end of the spindle holds the moderator in position on the spindle. It is provided with a head with notches N (fig. 68). A bent spring S^2 is secured at one end by means of a screw S^3 to the body of the moderator, while the other end is slit into two prongs to allow of a small projecting pin P^1 from the metal piece P (figs. 65, 66 and 67) passing between it and engaging one of the notches N of the screw S^1. When the moderator is inserted on the spindle, it pushes the spring S^2 outwards and the pin P engages in one of the notches of the screw S^1. In loosening or

tightening the screw S^1 the pin P^1 has to be disengaged from the notched screw S^1 by pushing the moderator inwards. The deeper the screw S^1 is driven into the spindle, the greater is the force exerted by the spring S^2, and the further in is the moderator put. Against the bearing of the moderator spindle is fitted a plano-concave, brass disc D called the *moderator cup* (figs 65 and 66) through which the spindle of the moderator passes. The concave surface of the cup faces the moderator. On one of the sides of the moderator weight, adjacent to the cup, is screwed a flat spring S (fig. 69) provided at its free end with a few wrappings of tow or jute J, called the *friction brush*

When the moderator is revolving slowly, this brush lies clear of the concave side of the moderator cup, but when the weight flies out the brush rubs against the cup and damps the speed. The position of the brush relative to the moderator cup is regulated by means of the notched screw S^1; the further in the screw is put, the smaller the circle described by the brush on the cup. It was seen in considering the action of the governor how the centrifugal force of the rotating weight counter-balances the driving force and maintains uniform motion. In the case of the moderator, an additional check is provided by regulating the friction of the jute brush on the cup, on which is dependent the amplitude of the weight. The number of spirals of the springs S in action can be reduced or increased as in the case of the *governor*.

153. In addition to this the speed of the receiver is controlled by the application of an electro-magnetic brake which is constructed as follows :—On the frame-plate P^3 (fig. 24) surmounting the driving gear of the receiver, are fitted two coils C (fig. 66) arranged one on either side of the fly-wheel F (figs. 24 and 66). The coils are joined in series and wound to a resistance of 40 ohms each, the two ends being led to terminals as shown in fig. 29.

The armature **A** (fig. 66) fitted in front of the cores is furnished with anti-contact surfaces of brass to avoid sticking due to residual magnetism. The coils are well raised over the frame-plate P^3 (figs. 24 and 66), and the armature is fixed across a vertical support V which is pivotted on two screws. A flat spring adjustable by means of a screw against which it works is fitted to the vertical support V and supplies the rest force ; the play of the support being regulated by an adjustable capstan headed screw.

To the support V is attached a small tube T, provided with a worm on the outside and a groove on the innerside. A smaller tube provided with a lug enters T, the lug keying into the groove in T. One end of the smaller tube is wormed whilst the other end carries a cork brake which abuts against the fly-wheel F and strikes it whenever the armature is attracted. A notched nut N^1 (fig. 66) screws over the two tubes and holds them in position. A small helical spring provided with a sharp stud at one end engages with one of the notches in N^1 and keeps it from working out; the whole is thus held securely in position.

154. In paras. 70 and 71 a description of the contact making device was given.

As may be seen from figs. 29 and 30 the stud S^1 is connected to one of the terminals of the brake magnet and to a local battery of 20 volts; this battery as will be seen in Chapter VIII is not joined direct to S^1 but through ring VI and either segments 2 and 3 or 7 and 8 of the third ring according as the first or second receiver is concerned. Studs S^2 to S^6 are similarly joined to either segments 1 to 5 or 6 to 10 of the first ring. Terminal S^7 which is connected to the contact making device is also led to the brake magnet. The brake magnet was said to be earthed once in each revolution, and if the brush on ring III transits either segments 2 and 3 or 7 and 8 whenever this earthing takes place, the circuit of the local battery will be closed through the brake magnet and thus work it. It may, however, happen that the contact between G and G^1 (fig. 30) is made either before or after the brushes transit the above segments and the circuit of the local battery cannot in these cases be closed. Since, however, the receiver type-wheel is revolving from 3 to 4 revolutions per minute faster than the distributor brushes, it will gradually gain on the latter until the cam works the contact making device at the same time as the brushes are passing over the segments connected to the local battery. The gain of the cam on the brushes is progressive and the duration of the local current through the brake magnet will fluctuate and work the brake with more or less force according as the contact making cam is more or less in phase with the transit of the brushes across the above-mentioned segments. The best action of the brake is obtained when it is attracted at each revolution.

155. The moderator should be adjusted to give the type-wheel a velocity of 184 revolutions a minute. The speed may be counted by insulating the circuit of the brake magnet, by placing a piece of paper between G and G^1 (fig. 30) and resting the finger lightly against one of the springs F F^1 (fig. 30). There should be no variation in speed, during several minutes, with a variation of amplitude. To increase speed, reduce the number of spirals in action and *vice versâ*. The same rules which regulate the governor are applicable to the moderator.

The test for the correct action of the brake magnet is to remove the receiver from the supporting base and connect stud S^7 to earth. The brake will thus be actuated at each revolution of the distributor and should stop the clockwork in from 8 to 10 revolutions.

156. The brake cork should project a trifle under an eighth of an inch from the tube containing it. The action of the brake depends on the tension of the flat spring which affords the rest

force to the armature ; this tension should be just sufficient to return the armature to its position of rest, and the play of the armature should not be too large. The fly-wheel and cork should be clean and free from oil.

157. The cam on the type-wheel axle is fixed by a clamping screw and its position on the axle may need adjustment. When the brake magnet battery is connected to segments 2 and 3 and and 8 of ring III, the position of the cam is adjusted as follows :—

Turn the axle till the middle of the appendix shuttle (fig. 28) is exactly in line with the foot of the third combiner-pin, on the opposite side of the wheel, then turn the cam on the spindle till it just commences to raise the balance lever L (fig. 30) and tighten up the clamping screw.

158. The practical test for synchronism between the distributor and receiver consists in transmitting the letter T continuously on the keyboard attached to the receiver required to be tested. If the receiver is running fast, instead of a series of the letter T the following will be imprinted—T U A letter space S T—; on the other hand, if the receiver is running too slow, the letters come in the reverse order, namely—T S letter space A U T—. The moderator speed should be decreased or increased as required until a series of the letter T is obtained. It may happen that the brake magnet is not acting, in which case the receiver will run fast, this should be ascertained before the moderator is touched.

Failures of fifths or of first may very frequently be due to the speed of the receiver being too fast or too slow, respectively and the rate of revolution should always be verified.

CHAPTER VIII.

TERMINAL WORKING.

159. Having seen how the various instruments employed in a Baudot installation are constructed and adjusted to function properly, a description of how they are connected up electrically for actual work is next necessary. Fig. 71 is a complete diagram of the connections in a double terminal installation.

160. A special feature in a Baudot set is the test box which consists of two ebonite terminal boards to which all the wires in the installation are led for purposes of testing or effecting any alterations in the connections.

The terminal boards of the test box consist of two flat pieces of ebonite E, about half an inch deep, into which brass screws S are fitted in the manner shown in fig. 70, at distances about half an inch apart. Into the screws S are fitted smaller screws U and L. The wires leading from the distributor are terminated at the lower ends of the screws S and secured to them by the screws L, while those connected to the other instruments in the installation are led to the upper ends of S and similarly secured by means of the screws U. The wires connected to the upper ends of S are passed through and secured to brass sleeves B by means of small screws S^1. The sleeves are encased in slips of ebonite E^1 which keep them from coming in metallic contact with each other. The sleeves are filed down at one end into forks F which slip in on to the screws U and are secured by them.

There are 9 terminals on the first board. The first two terminals marked A, and numbered 8 in the diagram (fig. 71), are connected together by a copper strip and joined to the relay. All the wires in the installation required to be connected to the relay are joined to these terminals. The next two terminals marked B, and numbered 9, are connected together and joined to the positive main battery. The next two terminals marked C, and numbered 10, are connected to the negative main battery. All connections leading to the positive and negative main batteries are joined to the terminals marked B and C respectively. The last three terminals marked D, and numbered 7, are connected to earth, all the earth connections are joined to these terminals. It may be noted here that all wires leading from the several instruments to the above terminals are numbered as above. The other terminal board, which is fitted at right angles to the first, is provided with 42 terminals consisting of three sets of 11, 14, and 14 terminals, and three others of a single terminal each. The lower ends of the first 10 terminals are connected to the first 10 segments of ring I of the distributor, whilst the upper ends of terminals 1 to 5 are connected to studs 1 to 5 of the first receiver (fig. 71) and the upper ends of terminals 6 to 10 are similarly connected to the second receiver. Terminal 11 is connected to the 11th segment of the first ring at the lower end and the upper end is normally left unconnected. These 11 terminals are bracketted ring I (fig. 71). The lower ends of the next set of 14 terminals, bracketted ring II, are connected to the fourteen segments of ring II of the distributor while the upper ends are connected as follows. The first five to contact springs F (figs. 4 and 6) of the first key-board, the next five similarly, to the second key-board and the last four, at a corrected station, to the relay. At a *correcting* station, terminals 11 and 12 are joined to the relay, and terminals 13 and 14 to the positive and negative main batteries respectively; these connections are made in the test box. Of the second set of 14 terminals bracketed ring III, only six are utilised. The lower ends of the terminals are connected to the 14 segments of ring III of the distributor. The upper ends of terminals 2 and 3, 5, 7 and 8, and 14 are connected as follows :—terminals 2 and 3 to the brake magnet of the first receiver, terminal 5 to the key locking magnets and telephone of the second key-board ; terminals 7 and 8 to the brake magnet of the second receiver and terminal 14 to the key locking magnets and telephone of the first key-board. It will be noticed that the leading wires from these terminals are all marked 6 ; this is because they are all led to terminals marked 6 in the key-boards and receivers (fig. 71).

The lower ends of each of the last three single terminals marked rings IV, V and VI are connected respectively to similarly marked rings of the distributor, whilst the upper ends are connected as follows :—terminal ring IV to the relay tongue, terminal ring V to line, and terminal ring VI to a positive battery of 20 volts, *i.e.*, the brake local battery, as it is termed.

161. A double Baudot terminal set is fitted on three tables each measuring 2′ 3″ by 2′ 9″, arranged in a line alongside each other. On the first table are fitted the distributor, the Morse apparatus, the test box, the Baudot relay, and the terminal screws including the leak resistance. On each of the other tables are fitted a key-board and receiver.

162. The Morse apparatus consists of a G. P. O. non-polarised relay and a Morse key connected as shown in figure 71, with a Post Office sounder in the local circuit of the relay. The line is connected through a galvanometer either to Morse or Baudot by means of a two-way switch.

163. There are six main terminal screws to which the Line, Earth and Batteries are connected. They are marked as follows :—

PL (Pile locale) Local battery.
PA (Pile d' Aiguillage) Receiver battery.
— Negative main battery.
+ Positive main battery.
L Line and leak.

These screws are of novel design and deserve special notice.

A brass bolt B (fig. 72) cast solid with a circular disc D is secured to the table by means of screws S which pass through the disc. The bolt is screw cut and a washer W screws on to it and secures the wire L', leading to the test box, between it and the disc D. A slip of brass B' fits over the bolt but is insulated from it by means of an ebonite collar E. The main wires M leading to the system are connected to B' by means of the screw S'. A binding nut N screws over B' and when locked tightly on to it places the bolt B in metallic connection with B' and through it with the wires leading to the test box. The main leads M are thus connected to the test box only when the nut N is driven home, and a means is thus afforded of insulating any of the main wires by just unscrewing the nut N a turn or two.

164. The leak resistance or rheostat which is fitted next to the line terminal L, consists of a bolt B (fig. 73), similarly fastened to the table, over which a washer W fits and secures the wire L' leading to the test box. Over W is fitted a second washer W' to which a strip of copper C, connected to the adjacent line terminal L as shewn in figs. 72 and 73, is soldered. An ebonite collar E insulates W' and C from the bolt B and washer W. Brass bobbins B', B², B³, containing coils of wire wound to a resistance of 3,000 ohms each, are placed over W'. The bobbins are insulated from the bolt B by means of insulating bushing I. The ends of each of the coils B,' B², B³ are soldered to the brass cheeks of the bobbins. Above the bobbins fits a third brass washer W² provided with a lug L which keys into a groove G in the bolt B' (fig 72). When the binding nut N is tighened the lower cheek of the bobbin B³ is brought firmly in contact with the washer W' and connected strip, and the upper cheek of the bobbin B' is placed through bobbins B' and B² in connection with the nut N, and through it with the bolt B and the leading wire L' to the relay. The outgoing currents are thus split at the terminal and passing through the connecting strip to the leak resistance and relay, operate the latter and hence the local receiver. A local record of all transmitted signals is thus furnished and helps to check faults in sending.

The bolt B is constructed to take a maximum of five bobbins. The resistance of the leak therefore ranges from 3,000 to 15,000 ohms. The current through the leak should not be less

With lines requiring a voltage ranging fron 90 to 140 volts, three bobbins are generally used. The working current for a Baudot relay is fixed at 15 milliamperes and the batteries are regulated to give this current when measured at the distant end.

163. It was mentioned that there are four *battery* terminals. To the one marked PL is connected a battery of 20 volts which is joined to the sixth ring of the distributor through the test box. This battery as seen works the cadence telephone and key locking magnets as also the brake magnets of the receiver.

To terminal P A is connected a battery of 10 volts which is joined to the fourth ring of the distributor through the relay contacts. This battery works the electro-magnets of the receiver and the electro corrector.

To terminals marked + and — are connected the main batteries positive and negative.

166. The incoming and outgoing currents may now be traced and their action on the several instruments explained.

The corrected station receives on the first arm and transmits on the second; the key switch of the first arm is therefore put to *receive,* and that of the second arm, to *send.* At the correcting station the key switch of the first arm is put to *send* and that of the second arm to *receive.* Before proceeding, it may be repeated that the brushes of rings I, II and III at each station simultaneously for all practical purposes pass over similarly numbered segments on their respective rings, *i. e.,* the three brushes enter on, say, segment 1 of their respective rings simultaneously.

167. The positive and negative mains are led through the test box to the front and back plates of the sending key-boards. When a letter is signalled, say at the correcting station the five impulses are transmitted by means of the springs F (figs. 4 and 6) spiral spring S and terminals 1 to 5 (fig. 5) to the test box and through it to segments 1 to 5 of ring II (fig. 71), then through the brushes and brush-holders to ring V, which is joined to line through the test box. At the line terminal L a dual path is afforded; one through the leak and relay to earth, the other through line to the distant station. In passing through the leak, the relay tongue is sent against the working stop for all positive impulses. The circuit of the PA battery of 10 volts is then closed through the working stop and tongue of the relay, the test box, ring IV of the distributor, and segments of the first arm of ring I, then again through the test box and receiver electro-magnets to earth. The electro-magnets of the receiver are thus worked for each outgoing positive impulse. The negative impulses send the relay tongue to the rest stop and the local battery being thus cut off the receiver electro-magnets are not actuated for negative impulses.

168. At the distant station, the incoming impulses pass from terminal L through the test box and ring V of the distributor to ring II, then over segments 1 to 5 of ring II, through the test box to the contact springs F of the first key-board and, with the key to receive, through the back plate, key switch and stud S^1 (figs 5 and 71)through the relay coils to earth. The relay at the distant (corrected) end in working similarly actuates the receiver through the segments of the first arm of ring I, the transit of the local current through the receiver being the same as that traced in para 167.

169. Immediately after receipt of the five impulses from the *correcting* station, the *corrected* station transmits from the key-board on the second arm, segments 6 to 10 of ring II. The transmitted impulses pass through these segments and ring V to the line terminal. Their action on the second receiver at the transmitting *corrected* station is the same as that explained in para. 167.

170. At the receiving or *correcting* station the impulses arrive between segments 6 and 12, the position being dependent on the retardation of the circuit. From these segments they pass through the second key-board and relay to earth. The relay in responding to the positive impulses actuates the receiver on the second arm either through segments 6 to 10 or 7 to 11 of ring I which are set to correspond to the arriving impulses on ring II. The course of the incoming current in fig. 71 is indicated by the continuous arrows numbered 1 to 14. The outgoing are indicated by the dotted arrows 1 to 8, the leak circuit being indicated by dotted arrows numbered 9 to 14.

171. The cadence current is indicated by the double-headed arrows 1 to 5 for the key-boards, and the brake magnet current by the double-headed arrows 6 to 10 for the receivers.

172. The local currents from the PA battery working the electro-magnets of the receiver, are indicated by the feathered arrows 1 to 8 for the receivers ; the section indicated by the feathered arrows 1 to 3 being common to both receivers.

173. It will be seen (fig. 71) that both the key-boards and receivers are connected each to the terminal numbered 7, which is connected to earth. The circuit of the local batteries P A and P L is thus always completed through earth.

174. It is plain now how the incoming and outgoing positive impulses in sending the relay tongue against the working stop and closing the circuit of the PA battery, work the receivers which are set, through the movable arms of ring I to correspond to the incoming and outgoing impulses.

175. At the correcting station, segments 11 and 12 are joined to the relay, and the synchronising impulses are sent from terminals 13 and 14 of ring II (fig. 71) which are joined to the positive and

impulses are received on two of these four segments, the movable contact No. 12 of ring I being placed so as to receive the positive impulse on ring II near the end of segment 13.

The circuit of the electro-corrector is worked by the PA battery whenever the relay tongue is carried to the working stop and the brush of ring I is simultaneously on the movable contact. At the correcting station, the electro-corrector is disconnected from the movable contact.

175. The cadence current is transmitted through segments 14 and 5 of ring III, one-forty-second of a second before the brushes on ring II transit segments 1 and 6 respectively; the operator is thus warned to bring the keys down in due time.

It was explained in paras 154 to 158 how the receivers are synchronised with the distributor by means of the brake magnets. The current from the PL battery is transmitted through segments 2 and 3, and 7 and 8 for the first and second receivers respectively as indicated by the feathered arrows (para. 172).

176. Before commencing work, the following should be carefully attended to. The distributor plates should be clean and the brushes properly adjusted. The electro-corrector should be adjusted to function properly and the contact points of the key-boards and relay burnished. The relay should be in good adjustment, the governor and moderator speeds correct, and the brake magnets should check the receiver speed so that correct printing is obtained. The impressions should be clean and firm, and the impression arm should be locked and unlocked easily. The switches of the keyboards of the two arms should be put to the required position and all parts properly oiled. Having carefully attended to the above points, the line should be put on and the distant station called up on the Morse circuit.

The incoming current should next be measured and *equalised*. The corrected station will then ask the correcting station to *turn*, i.e., to start the distributor and switch to Baudot, and after noting on the Morse the regular arrival of the correcting impulses the corrected station will itself start its distributor and switch to Baudot. The corrected station will then synchronise its distributor brushes to those of the distant station. It was shown in Chapter VI how synchronism is obtained and maintained. The best effect is produced when the correction is obtained *once in two turns*. Frequent correction indicates that the brushes are going too fast, and the speed should be reduced and *vice versâ*.

177. Proper correction being obtained, the corrected station should after calling the attention of the correcting station by the alternate depression of the fourth and fifth keys transmit positive impulses from the third key, *i.e.*, the letter Y or figure 3. The *correcting* station will then adjust the movable (second) arm, connected to the receiver, until the letter Y is imprinted. The way to

effect this is to move the arm in the same direction as the rotating brushes, *i.e.*, counter clockwise, till a 2nd is recorded, *i.e.*, till the incoming 3rd impulse operates the 2nd electro-magnet of the receiver. The position of the arm should then be marked, and the arm moved clockwise till the incoming impulse operates the 4th electro-magnet. Having marked this position of the arm also, it should be moved to take up a position midway between the two marks. The adjustment of the movable (sending) arm for the local record may be similarly effected. After obtaining thirds, both stations should transmit the letters T G and adjust the relays, giving slight marking for failures, or spacing for extras.

178. It should be noted at the corrected station that the two moveable arms are not placed too close to each other, *i.e.*, segments 5 and 6 of ring I, should be placed at least a distance of one segment apart. To effect this the movable contact should be shifted clockwise to the right and a new position for thirds obtained. The correcting station will have to take up a new position on the receiving arm whenever this is done.

179. Varying line conditions sometimes cause bad receiving and necessitate a change in position of the movable contact and arms. A condition most marked at the correcting station.

180. In practice, when obtaining correction, the arrival of the correcting impulse on the movable contact may be hastened by touching the governor axle and reducing the amplitude, thus causing the speed to be temporarily increased during the period that the weight takes to fly out again. The incoming correcting impulse may be drawn back by pressing the relay tongue against the working stop and actuating the electro-corrector for each turn, this is only done when the correcting impulse is observed either on the 1st or 2nd segments, *i.e.*, when it is slightly to the left of the movable contact.

181. If variations in speed are noticed, both stations should verify the action of the governor. The corrected station should note the nature and frequency of the correction. The driving weight should be increased, and after thus increasing the amplitude of the governor, the correction should not vary in frequency. Increased frequency would indicate that the tension of the governor springs is insufficient and decreased frequency that the tension is too great. The controlling action of the governor may also be tested by decreasing the driving weight and noting the frequency of correction. The correcting current may be allowed to pass along the receiving segments on the first arm, and the number of times the current is received on each segment, as indicated on the receiver electro-magnets, for different amplitudes of the governor may be noted. If with a smaller amplitude each electro-magnet is operated a less number of times, the reduction of amplitude has increased the speed. The same tests should be made by the correcting

station, which should disconnect the battery from the 13th and 14th segments and request the corrected station to transmit a positive impulse, say from the third key. The passage of this impulse along the receiver electro-magnets will show whether the speed has increased or decreased under varying tests. It should be remembered that the correcting station normally runs at a lower speed than the corrected station : increased speed at the correcting station will be indicated by the electro-magnets being operated more frequently and *vice versâ*. The means adopted for remedying the faulty action of governor have been given in Chapter VII. In adding weight to the governor care should be taken not to upset the balance, otherwise variations in speed will result. It may be noted here that the above tests depend on the resiliency of the springs.

181. Faulty reception may sometimes be due to a bad position of the movable arms. *e. g.* the occasional impression of the letter B for Y shows that an extra impulse is being received on the 4th segment of ring I, *i.e.*, segment 4 of ring I is slightly overlapping the position of the third impulse on ring II. The slight movement of the movable arm in the same direction as the brushes will obviate this; similarly a counter-clockwise movement is necessary if an I is occasionally recorded instead of Y thus indicating extra seconds. It may be necessary to move the movable contact, for instance, for failure of firsts to the left.

182. Faulty reception of this nature may also be due to variations in the strength of the PA battery. This is noticed in offices using accumulators which are frequently switched on or off charge. It may thus happen that the normal voltage is slightly increased or decreased.

183. The variation in the voltage of the P A battery affects the rapidity in functioning of the electro-corrector which, being adjusted to produce proper action at a certain voltage, affects the previous adjustment of the movable arms, *e. g.*—a decrease in voltage will retard the action of the electro-corrector and result in a larger section of the movable contact, being traversed by the brush, whilst the positive correcting impulse is on, thus increasing the frequency of correction and affecting the synchronism.

183. Retardation on the line if variable will affect the reception of signals *e. g.* increased retardation will result in extras, *i.e.*, B, for Y, and reduced retardation in extras in the reverse order, *i.e.*, I for Y.

184. If the angular distance of the brush arm of the 1st ring relative to the other arms is altered (para. 127) the effect is the same as if the movable contact is shifted, and the adjustments at both stations require to be performed again.

185. Faulty reception may also be caused by incorrect action of the electro-corrector due to a mechanical fault.

186. If the negative battery is insulated at the correcting station, the electro-corrector will be worked at every turn and synchronism will be lost, a succession of P's will also be recorded on the first arm at the corrected station and the local record at the correcting station; when the negative is off at the corrected end, the letter P will be frequently recorded on the second receiver at both stations, but synchronism will be maintained.

187. When the local record is good at the sending station, failures may be due either to light sending or faulty adjustments. The transmitted impulses though producing a good record may yet result in faulty receiving at the distant end. Failure of thirds is frequently produced by insufficient pressure on the third key. Failures of firsts are due sometimes to late depression of the first key, the brush having passed on to the second segment before the key was brought down. Failures of firsts and thirds due to the above causes are invariably evidenced in the local record.

188. Extra fourths and fifths may be caused by the key locking magnets being too strong.

In all cases of incorrect printing the home instruments should be tested, on the lines indicated in the preceding chapters, before attributing the fault to the distant station.

189. Variations in speed are always evidenced by bad printing. Sudden slight variations in speed may not throw out the correction though affecting the printing.

190. In cases of prolonged bad work the various leads should be tested for continuity by means of a galvanometer and a dry cell. Tests for continuity should be conducted from point to point. The continuity of the leads from ring I of the receiver and electro-corrector can be ascertained by putting the relay tongue to the working contact. If all the leads are intact, a succession of P's will be recorded on the receiver, and the electro-corrector will be actuated for each turn. Tests for insulation should also be conducted with a larger battery and a resistance box.

As a rule, it is wise for each station to test its own apparatus whenever a fault comes on, in preference to assuming that it is due to the distant end.

191. In measuring currents before starting work it is well to note and record the extent to which the galvanometer needle is deflected for incoming and outgoing currents. Variations in line condition will be indicated by variations in the deflections of the galvanometer, and will serve as a rough and ready means for locating faults *e.g.*, if the measured outgoing current on starting work indicates a deflection of 50 degrees on the galvanometer, and on measuring again an hour or so later the deflection is observed

to have risen to 60 degrees, it is an indication either that the insulation of the line is falling or that there is partial earth. The depression of the Morse key with the line insulated at the distant end will give a rough indication of the condition of the line *e. g.* a sudden dipping of the galvanometer needle indicating an intermittent earth and a steady deflection half way down, indicating heavy leakage. Good insulation will be shewn by a deflection of the needle away from zero and then a return to zero at make and break of contact of the morse key, indicating the currents of charge and discharge. A variety of observations of this nature will facilitate the tracing of faults.

CHAPTER IX.

TRANSLATION.

192. In Baudot, as in other systems of telegraphy, there is a limit to long distance working, owing to the incoming current being considerably weakened by leakage, and to heavy retardation. Increase of battery power does not in all cases overcome the first difficulty and translation or relaying at some station centrally situated between the two terminals has to be resorted to. The function of a Baudot translation station is, (1) to automatically re-transmit the currents received from both sides, (2) to alternately send correcting impulses to both terminal stations, and (3) to maintain a local record of passing signals and thus check the state of communication,

193. The principle instruments in a translation set are,

1. A distributor, with a front and back plate,
2. A receiver,
3. Five relays mounted on a platform,
4. Four six bar turn-over roller switches,
5. One ten bar turn-over roller switch,
6. One transmitter or keyboard with telephone attachment and desk,
7. Two galvanometers,
8. Two non-polarised electro-magnets termed " speakers,"
9. A set of four leak resistance coils and,
10. A complete Morse set as ased in *terminal* working. There are in addition to these, the test box, terminal screws, and other accessories used in a terminal set.

194. The distributor has two sets of plates, called the *front* and *back* plates, fitted one in front and the other behind, and two sets of brushes fitted on the same axle. The clock work is the same as in the terminal sets, with the exception that the electro-corrector and connected mechanism described in Chapter VII (paras. 143, 144) are not used. The translation distributor thus, only contains the two wheels W and W1 (fig. 54) and the axle A on which the brushes are fixed. The distributor plates are also arranged differently to those used in a terminal.

The front plate (fig 74 A) consists of three rings arranged as follows ;—

Ring I consists of two large segments numbered 1 and 2; these segments are mounted on movable ebonite arcs, similar to the movable arms of ring I of the terminal plates, and can be adjusted as required. The second ring consists of 12 small segments numbered 1 to 12, two of these, 6 and 12 are fixed, whilst the other ten *viz.*, 1 to 5 and 7 to 11 are mounted on the movable ebonite arcs, which carry segments 1 and 2 of the first ring and are thus also adjustable, relatively to the back plate. The segments 1 to 5 and 7 to 11 are fixed in recesses, cut out of segments 1 and 2 of ring I, in such a way that the brush which travels over ring I is common to the segments of ring II as well. These segments are insulated from those of ring I and the brush thus alternately passes over the segments of Ring I and II. Ring III consists of four fixed segments numbered 1 to 4, segments 2 and 4 are opposite to 6 and 12 of ring I and are used for the cadence, whilst 1 and 3 which overlap the arc covered by the other segments of rings I and II are placed in connection alternately with the segments of these rings by means of the revolving brushes. Only one pair of brushes revolves over these three rings.

The back plate consists of six rings, rigidly fixed on an ebonite block, the outer or first ring consists of 12 segments, ten of these, numbers 1 to 5 and 7 to 11, are of the same length, while 6 and 12 are about double the length of the others.

Ring II consists of 5 segments numbered 1 to 5; the 1st and 3rd being about five times the length of either segments 4 or 5, segment 2 being, only a little larger than either of these.

Ring III also consists of 5 segments, 1 and 4 being similar to to segments 1 and 3 ring II, and segments 2, 3 and 5 to segments 4, 5 and 2 of ring II respectively.

Ring IV consists of 4 segments, two of which, 1 and 3 are opposite to each other and are much larger than numbers 2 and 4 which likewise are opposite each other.

Rings V and VI are complete rings.

Three pairs of brushes, fitted on the same axle on which the brushes of the front plate are fixed, revolve over the backplate and place rings I and IV, II and V, and III and VI in connection with each other.

195. A test box is provided to which the wires from all the segments of the back and front plates of the distributor are led. As the construction of the test box has already been explained in para. 160, it will suffice to say that the one used in the translation varies only in arrangement.

196. The receiver is in all respects similar to the pattern used in terminal working.

Fi relays are provided in translation, only three of

The first or *receiving* relay is worked by the incoming currents from the line and in turn works *the second* or *re-transmitting* relay, which is connected in the local circuit of the receiving relay. The two other spare relays are provided to replace these two, by means of a switch, when necessary, *e.g.*, for cleaning or for purposes of adjustment. The re-transmitting relay in being worked re-transmits to the line, impulses from the main batteries which are joined to contacts 5 and 7 (fig. 74). These re-transmitted currents bifurcate at the sixth terminal of the 10 bar switch and pass through a leak and the fifth relay, called the *local* relay, which is used to actuate the receiver connected in its local circuit.

The re-transmitted current after passing through the leak and local relay is doubled back through the coils of the retransmitting relay. The tongue of the re-transmitting relay is thus retained against contacts 5 or 7, a trifle longer than the local currents from the receiving relay tend to keep it. In addition to this, a non-inductive shunt of 200 ohms resistance is joined parallel to the coils of the re-transmitting relay, and by affording a path for the extra currents generated at make and break help (*a*) to reduce sparking at the contacts of the receiving relay and (*b*) to prolong the action of the local current from the receiving relay. The interval of contact of the re-transmitting relay tongue is thus prolonged and the re-transmitted impulses are therefore of longer duration than the received ones.

198. The above-mentioned five relays are mounted on a wooden platform supported on springs. The vibration of this platform, due to the working of the mechanism on the table, is at right angles to the play of the relay tongues and does not therefore interfere with their working. The shunts of the re-transmitting relays are fitted on the platform, and when the re-transmitting relays are placed on the latter their coils are connected parallel to the shunt.

199. The speakers consist of two non-polarised electro-magnets or sounders wound to a resistance of 100 ohms each. The play of the armature and the tension of the antagonistic spring are regulated each by an adjustable terminal screw fitted one above the other behind the wooden cover in which the sounder is encased. The coils are connected to two terminals fitted in front of the cover.

200. In a translation set, only one receiver and transmitter are used, and switches of some kind are therefore necessary to put these into circuit on either side of the translating station. Four six bar two-way turn-over switches are provided for this purpose, two each for sending and for receiving in either directions. Each switch consists of a cylinder of ebonite E (fig. 74 B), through which holes are bored and cased with fine brass sleeves S to receive small brass cylindrical contact pieces. These contact pieces are constructed as follows: A peg of brass P fitted with a spiral spring S^1 slips into a cylinder C of larger diameter, and

closed at one end, the tension of the spiral spring pushes both the peg and cylinder C outwards. The ebonite roller E contains six such contact pieces and is provided with a handle H, by means of which it is turned through an arc of about 70 degrees. The lower portion C of each contact piece is always in connection with the rounded section of a brass block B fitted directly beneath it, whilst the upper portion can be placed in contact with one of two bevelled brass blocks B^1 and B^2 placed above the contact pieces, and secured to the woodwork of the switch by clamping nuts. Each of the six blocks B, B^1, and B^2 are provided with screw terminals, marked *x*, *y*, and *z*, respectively, in the diagram fig. 74 to which the leading wires are secured.

For easy reference these six screw terminals connected to the blocks B, B^1, and B^2 will be termed the *x*, *y*, and *z* terminals. The *x* terminals being connected to the block B may be placed in connection with either the *y* or *z* terminals by turning the switch handle to the left or right respectively. A fifth turn-over switch consisting of ten bars and constructed similar to the six bar switches, is provided for changing the *receiving* and *re-transmitting* relays of the first and second set which are respectively connected to the *y* and *z* terminals of the switch. This switch is marked E on the diagram and will be referred to as such.

201. The two switches, marked A and B (fig. 74), are termed the *sending* switches, because by turning the switch handles to the left, the key-board is connected to the re-transmitting relay and the translation station can send to either of the terminal stations according to which of the two switches is turned to the left, *i.e.*, to *send*. When the A and B switch handles are turned to the right, *i.e.*, the normal position, the tongue of the receiving relay is placed in connection with the coils of the re-transmitting relay through terminal 2 of the switch E, *x* and *y* terminals of either of the switches A or B, segments 1 to 5 or 7 to 11 of ring II frontplate, segment 1 or 3 of ring III, frontplate, terminal 8 of switch E and terminal 8 of the re-transmitting relay. The two switches marked C and D are termed the *receiving* switches, because by turning the switch handles to the left the receiver is placed in the local circuit of the local relay, and the translation station is in a position to record received signals from either of the terminal stations according to which of the two switches is turned to the left, *i.e.*, to *receive*. In translation, the handles of the sending switches and one of the receiving switches are always turned to the right, only one receiving switch handle is turned to the left to keep a record of passing signals. No two sending nor two receiving switches must be turned to the left at the same time as it is impossible to send or to receive in both directions at the same time, on one key-board and receiver. When the C and D switch handles are turned to the

202. There are eight terminal screws marked and connected as follows :—

L^2 (Ligne 2) Second line.

PR—(Pile du relais—) Re-transmitting relay negative battery, 10 volts.

PR+ (Pile du relais +) Re-transmitting relay positive battery, 10 volts.

PL (Pile locale) Local positive battery, 20 volts.

—Negative main battery.

+ Positive main battery.

L^1 (Ligne 1) First line.

T (Terre) Earth.

These terminals are connected to the apparatus as follows :—

L^2 to ring VI backplate.

PR—to x terminal 3 switch E, and to terminal 9 of the key-board.

PR + to x terminal 1 of switch E and to terminal 8 of the key-board.

PL to the working contact of the local relay, to segments 2 and 4 of ring III front plate and to segments 2 and 4 of ring IV backplate.

—main negative to x terminal 7 of switch E and to segments 5 and 3 of rings II and III respectively backplate.

+ Main positive to x terminal 5 of switch E and to segments 4 and 2 of rings II and III respectively of the backplate.

L^1 to ring V backplate.

T—To segments 2 and 5 of rings II and III respectively backplate, to terminals 7 of the receiver and of the key-board, and to the W terminals of the receiving and re-transmitting relays.

203. The segments of the distributor front and backplate are connected through the test box as follows :—

Backplate—Ring I.—Segments 1 to 5 and segment 12 are joined to the x terminals 1 to 6 of switch C, segments 6 to 11 to the x terminals 1 to 6 of switch D, thus putting either the receiver or the speaker in connection with these segments; segments 12 and 6 providing the current for the brake magnets in the former case.

Rings II and III.—Segment 1 of ring II and 4 of ring III are connected to the x terminal 6 of the switch E, and thus to the tongue of the re-transmitting relay; segment 3 of ring II and segment 1 of ring III to the x terminal 4 of switch E and through it to the coils of the receiving relay. Segment 2 of ring II and 5 of ring III to earth, segment 4 of ring II and 2 of ring III to the positive main battery and segment 5 of ring II and 3 of ring III to the negative main battery. These last connections to the positive and negative main batteries provide the correcting currents to be emitted to the terminal stations, whilst the connection to earth provides for the line on the one side being earthed whilst the correcting currents are being emitted to the other side. In this way whilst allowing for the effects of retardation, the line in being earthed is discharged and facilitates a good reception.

Ring IV, segments 1 and 3 are connected to tongue of the local relay and segments 2 and 4 to the P L battery and furnishes the current through the brushes to the brake segments 6 and 12 of ring I.

Rings V and VI are joined to L^1 and L^2 respectively and thence to the line on either side, through the switch and galvanometers.

Front Plate—Ring I.—Segments 1 and 2 are joined to the *W* terminal of the local relay.

Ring II.—Segments 1 to 5 and segment 12 are joined to the *x* terminals 1 to 6 of the sending switch A and segments 6 to 11 to the switch B. These segments are thus put by means of the switches into connection with either the translation keyboard or the tongue of the receiving relay. In the former case segments 6 and 12 provide the cadence current and are insulated in the latter, at the switches.

Ring III.—Segments 1 and 3 are joined to the *x* terminal 8 of switch E whilst segments 2 and 4 are joined to similarly numbered segments of ring IV back plate and thus to the P L battery which provides the cadence current through segment 6 and 12 ring II front plate.

The *y* and *z* terminals 1 to 8 of switch E are connected to similarly numbered terminals on the first and second sets of relays respectively. The *y* terminals 1 to 5 of sending switches A and B are all connected together and joined to the *x* terminal 2 of switch E. The sixth *y* terminal in switches A and B is insulated to prevent the P L battery from being short circuited through the tongue of the receiving relay when the switches are turned to normal. The *z* terminals 1 to 6 of *sending* switches A and B are connected to similarly numbered terminals on the keyboard, and the *z* terminals 1 to 6 of receiving switches C and D are connected to similarly numbered terminals on the receiver. The *y* terminals, 1 to 5, of receiving switch C are strapped together and joined through one of the speakers to earth; the *y* terminals of the receiving switch D are similarly strapped and joined through the second speaker to earth. The sixth *y* terminal in both the receiving

204. The above practically details all the connections in a translation set. It may be mentioned before proceeding further that when the handles of the switches A, B, C, and D are turned to the right, *i.e.*, when the x terminals are joined to the y terminals the switches are said to be in normal position.

205. It was explained that the segments of the first and second rings of the front plate were adjustable; the range of movement is, however, limited. No moveable segments are provided on the backplate, but the plate is moved *en masse* for purposes of adjustment, relative to the front plate. One of the screws fixing the plates to the frame is provided with a handle by means of which it is made to hold or release the plate (para. 116).

206. Having described the instruments and connections the course of the incoming and outgoing currents may next be traced.

The incoming current, say from station A (Fig. 74) passes from terminal L^2 through the test box to ring VI on the backplate; then across the brushes to segment 1 of ring III, the test box, terminal 4 of switch E, across the switch and through the coils of the receiving relay (say first set) to earth. The course of the above is indicated by the arrows 1 to 8. The tongue of the receiving relay picks up a current, positive or negative as the case may be, from the P R battery which passes along to terminal 2 of switch E to the y terminals of switch A, and with the switch handle at *normal* along the x terminals 1 to 6 through the test box to segments 1 to 5 of ring II (front plate); then across the brushes to segment 1 (ring III) and the test box to terminal 8 of the switch E; across the switch and coils of the re-transmitting relay to earth. The course of the above is indicated by the arrows 9 to 16.

The re-transmitting relay tongue in working picks up a current, positive or negative, from the main battery, which passes along terminal 6 of switch E where it bifurcates and passes through a leak resistance and the coils of the local relay to the test box and segment 1 ring I front plate, then across the brushes to segment 1 ring III front plate, the test box, terminal 8 of switch E and the coils of the re-transmitting relay to earth. The duration of contact of the re-transmitting relay tongue is thus prolonged, and the re-transmitted impulses are therefore of longer duration than those received. The translation station thus not only re-transmits but also prolongs the attenuated received impulses and ensures firmer signals. The second path is formed through the test box and segment 1 of ring III backplate across the brushes to ring V and test box to terminal L^1, switch and galvanometer to station B. The course of the working stop. This current passes along the brushes to segments 1 to 5 ring I and the x terminals of the D switch to either the y or z terminals of the same switch, and hence to the speaker or receiver respectively. The course of the current is indicated by the arrows 31 to 36 and 37 to 40. The speakers and receiver are thus worked in the local circuit of the local relay. As only one receiver is employed, the signals from one side only, can be recorded at a time, the speaker indicating the signals from the other. It must here be noted that it is the re-transmitted and not the incoming signal that is recorded.

207. In transmitting, the translation station utilizes the keyboard to work the re-transmitting relay. To do this one of the sending switches A or B, according to whichever terminal station is being worked, is turned to the left as explained in para. 168. In the above position these switches, as previously mentioned, place the keyboard contact springs in connection with the segments 1 to 5 or 7 to 11 of ring II, frontplate.

To the back and front plates of the keyboard are connected the negative and positive, 10 volt, P R batteries respectively.

When the keys are operated, the course of the current as indicated by the arrows 11 to 24 and 25 to 30, and is identical to that of the current from the tongue of the receiving relay.

The cadence and key releasing current is obtained from the P L battery through segments 2 and 4 of ring III and segments 6 and 12 of ring II front plate.

208. A great deal at the translation station depends on the accurate adjustment of the brushes on the back and front plates of the distributor. The correct position of the brushes relative to each other should be as follows:—

Front Plate.—With the brush of the second ring at the middle of the sixth segment and that of the third ring at the middle of the second segment the brushes on the back plate should be as follows:—

Back Plate.—The brush of ring I should be at the middle of segment 6, the back plate being turned *en masse,* if necessary, to effect this.

In this position of the brush of ring I, the brush on ring II should be on about two-thirds of segment 2, and that on ring III about one-sixteenth of segment 3; with the brush of ring I on the middle of segment 12 the brush of ring II should be on one-sixteenth of segment 2 and that on ring III on two-thirds of segment 3. Each pair of brushes should be perfectly square, special care being taken of the brushes on the front plate and those transiting rings I and IV on the backplate.

209. Another method consists in adjusting the brushes of the back plate as follows. Place the brush of the first ring at the

beginning of the sixth segment, the brush of the second ring should be just entering on the second or earth segment. Now turn the brushes so that the brush of the first ring is at the commencement of the 12th segment, the brush of the third ring should be just entering on the fifth or earth segment of that ring. Having adjusted the backplate brushes, turn them till the brush of ring I, front and backplate, are each in the middle of segment 6, the backplate being moved *en masse* for the purpose.

210. Having attended to the adjustment of the brushes, and tested the receiver locally (para. 171), by turning the handles of the switches A and C or B and D both to the left the translation station should switch on the line and adopt the following procedure in getting into communication. The first point for attention should be the measurement of currents, after which the terminal station should ask the translation station to turn, *i.e.*, start the distributor and after noting on morse that the correcting currents are coming in regularly switch on to the Baudot apparatus by means of the two way switch.

211. After synchonism is obtained, *i.e.*, when correcting currents are regularly indicated on the corrector, the terminal station should draw the attention of the translation station by sending fourths and fifths alternately and on being answered by a repetition of the same signals from the translation station, should depress its third key. The translation station then repeats back what it receives, and the terminal station should adjust the movable contact 12 until the translation station signals back thirds.

212. The movable contact should be moved to the right if the translation station repeats seconds, and to the left if fourths are repeated. It may be noted here that the translation station can absolutely define the position of the movable contact at the terminal station, according as it places its segments of retransmission, because it is from these that the record of reception at the translation station is obtained. There is a certain relative distance between the segments of correction, and the third segment of transmission at the terminal station ; so it is that at the correcting or translating station the same relative distance between emission of the correcting currents and the position for the reception of the third must exist. In this latter case however the distance referred to is increased by the segments corresponding to the retardation of the circuit, but the period of retardation is definite and thus though the relative distance between the emission of the correcting currents and the reception at the translating station may not be equal to the distance between the segments of correction and the transmission of the third at the terminal station yet a definite ratio exists between the two. In altering the position of the movable contact this ratio must continue to exist and hence it is that the movement of the movable produces a change in the position of reception at the translating station, the segments [illegible]

recting currents being fixed. In putting the movable to the left the distance between correction and transmission is reduced and therefore at the translating station the distance between emission of the correcting currents and reception is also lessened, resulting in the current of reception being received at a point nearer to the segment of emission.

There should always be a good margin at the terminal station on either side of the movable contact. On no account however should the movable be put too much to the left, as in this case the last current of reception and the first of transmission will be from the same segments *i. e.* the 6th. It may occur that no position of the movable contact will produce a repetition of the third alone; in this case the translation should be asked to help by placing its re-transmission segments so as to receive a good third which it can then repeat. The re-transmission segments besides defining the position of the movable contact at the terminal station define also the time that the re-transmitting relay is operated, and should always be in a position such, that the re-transmitting relay is worked at the middle or height of the current passing through its coils.

213. When the terminal station receives a continuous repetition of thirds it should move its movable contact to the left slowly, so as not to lose the correction, as indicated by its corrector. When the translation shews by repetition that it is receiving a fourth the terminal should mark the position of its movable and then move it to the right and when the translation begins again to repeat seconds this position of the movable should again be noted and the movable contact placed in a positions midway between the two marks. Care should be taken that these movements are very gradual and performed slowly. The terminal station will then call up the trannslation on its fourth and fifth keys as before and on being answered send a succession of the letters T G which also the translation station will repeat the terminal will then adjust its relay giving a slight bias to marking for failures or to spacing for extras. The translation station will also verify the position of the movable re-transmitting segments on the front plate and the adjustment of its relays. When a good record of the letters T G is obtained by both stations they should exchange a few sentences, and the translation should ask the first terminal station to wait whilst the same preliminary operations are repeated with the other terminal station. On completion, the translation station will put the two terminals into communication and the latter will after exchanging a few sentences, commence work. It should be understood that when the first terminal station after adjustment with the translation is asked to wait, it should make no change in the adjustments but wait till called up by the distant station.

214. It has already been mentioned that a corrected station

always receives on its first arm and therefore obviously, both terminal stations on a circuit working through a translation will receive on their first arms and transmit on the second.

215. A very common fault in a translation is the reception of an extra first; this is due to the position of the brushes being such that the P L battery on segments 2 and 4 of the fourth ring is put by the brushes in connection with the first and seventh segments of the first ring, backplate. Similarly an error in the opposite direction, is caused by the local battery being placed in connection with the fifth and eleventh segments of ring I, resulting in extra fifths. With the adjustable segments of ring I (front plate) close to the 6th or 12th segments ring II the terminal station is liable to receive extra firsts or fifths, the re-transmitting relay being operated by the local battery on segments 2 or 4 of the third rings, front plate. These faults are due to an incorrect adjustment of the brushes and the directions already given will obviate them.

216. At a translation station it should be taken as a criterion that as all signals recorded on the receiver from one side terminal is a leak from the re-transmitting relay, if the reception at the translation is good, the fault can only lie with rings II and V or III and VI, in case the other side terminal does not receive well. Then again if the terminal receives well from the translation keyboard obviously the fault cannot be on these rings, for the keyboard operates the re-transmission relay and the currents from the latter are emitted along these rings.

217. The leak resistance should be such that the leak current stands at about 10 milliamperes, heavy currents passing through the leak will result in heavy sparking. Sparking may likewise be caused at the points of contact of the re-transmitting relay by a faulty action of the shunt and also when the brush leaves the small segments of ring II (front plate) and goes on the long segment of ring I.

218. Failure of firsts at a terminal station, working through a translation, sometimes occur although the terminal reads the translation correctly. This fault is sometimes due to an incorrect position of the movable contact at the distant terminal station. The movable contact should be put a trifle more to the right at the latter station. Similarly, extra firsts at a distant terminal station may be corrected by a small movement of the movable contact to the left. To a certain extent these two faults of failures or extra firsts may be remedied at the station observing it by moving its own movable contact to the left or right respectively. Extra fifths can likewise be eliminated by putting the moveable arm further away from the moveable contact, *i.e.*, moving it counter clockwise. A very slight alteration of these moveable parts puts these faults right. It must be remembered that all work-

in terms of space traversed by the brushes, a certain distance from the correcting currents; thus in the last case mentioned the extra fifths occurring whenever a fourth is transmitted shews that the current emitted on the fourth key overlaps the fifth at the receiving station and as the moveable contact corresponds relatively to the position where the correcting currents are coming in on ring I the moveable arm apparently is not in correct relation to the position on which the currents of reception are coming in, *i.e.*, the moveable arm is too close to the moveable contact.

219. Great care should be taken at a translation station to keep the points of the relays clean. A neglect of this precaution results in intermittent failures at the terminal stations although good printing may be obtained locally.

CHAPTER X.

CONCLUSION.

220. It is intended in this chapter to give any further *data* and information not already mentioned.

221. For long distance working it is found necessary to allow at the correcting station a larger margin for the period of retardation. The normal segments for the emission of the correcting impulses are the 12th and 13th of ring II. This is quite efficient when the period of retardation is equivalent to half a segment in each direction, *i.e.*, one segment in both directions. On long lines, however, the period of retardation is found to be as much as two segments, and hence the reception at the correcting station is performed on segments 8 to 12, Segment 12 being thus engaged at the correcting station, the correcting impulses have to be sent out from segments 13 and 14. This has become the universal practice in India irrespective of the period of retardation. Segments 6 to 10 of the first ring were shown as connected to the second receiver. It occurs, however, that owing to insufficient length of the connecting wires the second arm cannot be moved sufficiently to make 6 to 10 of the first ring correspond relatively to segments 8 to 12 of the second ring. Under these circumstances it has been found convenient to move the connecting wires of the second receiver to segments 7 to 11. No change is necessary in the connections of the second ring because the incoming impulses can reach the relay either through the contact springs and backplate of the second or inactive key-board, or direct from segments 11 and 12, which at the correcting station are joined to the relay. All alterations in the connections are effected in the test box. It will be noted that during the period of retardation, segments 6 and 7 of the second ring at the correcting station provide for the discharge of the line which is joined through the contact springs and backplate of the second key-board and the relay to earth. The relay may during the period of retardation be actuated by induced currents, but the receiver will remain unaffected as the brush of ring I does not traverse any of the segments connected to the receiver, the 7th segment of ring I, which has been connected to the first electro-magnet, corresponding to the 8th segment ring II. It will be seen that the line as mentioned above is earthed through the relay at the correcting station between transmission and reception, and assimilates the conditions existing at a translation station.

222. At the corrected station no change is necessary, the moveable contact only has to be moved counter-clockwise so as to correspond to the point at which the correcting currents are emitted. In practice, it is found that with the brush of the second ring at the end of the 13th segment, the brush of the first ring should be about a sixth of a segment beyond the right edge of the movable contact, which should be shifted to suit. The middle of the first segment, second ring, similarly must correspond to the middle of the first segment of the first ring. The above has been found to be fairly invariable. The movable arm of reception, *i.e.*, the second arm at the correcting station must be adjusted so as to coincide with the height of the incoming currents as already explained in para. 117.

At the corrected station, in fixing the position of the movable contact and hence of the first arm, the former should not be moved so far to the left as to bring the 5th segment, ring I, too close to segment 6. These two segments should always be a distance apart equivalent to at least that between any other two segments of ring I.

223. A double Baudot set besides being utilised for transmitting in opposite directions can be used for *diplex* working, *i.e.*, a station can transmit to the other on both the key-boards. When the *correcting* station is sending on both arms, the second arm will require re-adjustment so as to produce a correct local record. Obviously when segments 7 to 11 ring I, are being utilised for reception the arm will admit of no suitable adjustment, because segment 7 can never be brought to correspond to segment 6, ring II. At the corrected station which is receiving the position of the second arm will need re-adjustment, so as to obtain a good record of the incoming current. In practice, the second arm will have to be brought up to the first, so that the distance between the 5th and 6th segments is equal to that between any other two segments of ring I. It occurs that, if the position of the movable has been fixed so as to correspond relatively to the end of the 13th segment, ring II, no change will be necessary as the above requirements for diplex reception will be found to be fulfiled.

With the *corrected* station transmitting on both arms the position of its first arm will need alteration for the purpose of obtaining a good local record. Under the circumstances just mentioned above, no change will be necessary. At the correcting station the first, movable arm will require to be brought up to the second arm the relative distance between segments 5 and 6 being maintained. The segments of retardation at the correcting end in this case will lie between the correcting currents and the incoming working currents of the first arm. If the reception in double working was being performed on segments 7 to 11, it is feasible to receive diplex at the correcting station. The distance between the two arms being accurately adjusted, the connections of the first receiver can be shifted to segments 2 to 6. For the purpose of obtaining corrections to messages the receiving station, in diplex, turns over to *send* on its normal transmitting arm. In the latter case no local record will be obtained. In all the other cases mentioned above, the movable arms can be put back for the purpose of a local record. It must be here remarked that when turning from the "send" to the "receive" position the switch on the key-board will have to be manipulated accordingly. For practical purposes the two positions of the movable arms can be marked and the arms speedily shifted. It may be mentioned that when the *corrected* station is receiving (diplex), signals are more stable than when the *correcting* station is receiving; because in the latter case the disturbing effects of retardation are more prominent for reasons already mentioned in para. 120.

224. In the new sets of apparatus, now being brought out to India, the weight driven clockwork described in Chapter IV, is replaced by an electric motor. This motor, which gears direct with the distributor and the receiver, consists of a Gramme ring armature of eight sections, which revolves in a field of permanent magnets.

The commutator of the motor armature is connected through the brushes and an adjustable rheostat R (fig. 75) to a battery of 20 volts, the maximum resistance of the rheostat being about 195 ohms, consisting of two fixed resistances of 75 and 50 ohms respectively, and a variable resistance up to 70 ohms. With a resistance of 70 ohms in circuit the current is about 60 milliampéres and with the minimum resistance about 250 milliampéres. The speed is regulated by this adjustable resistance and by the governor or moderator which are fitted as explained below. At normal speed, *i.e.*, 180 revolutions per minute of the type-wheel or brush arms, the current utilised is between 70 and 80 milliamperes. The resistance of each coil of the distributor armature is 25 ohms and that of the receivers 5 ohms.

On either side of the armature axle are fitted two pinions. At the commutator end the pinion gears with a second pinion fixed on a spindle placed below the armature; this spindle carries either the governor or the moderator. The pinion on the other end of the armature axle gears with the wheels of the distributor or receiver, and takes the place of the sixth spindle (fig. 24) of the *weight driven* clockwork.

Local synchronism between the distributor and the receiver is effected by an electro magnet operated through the usual brake segments of ring III. The armature of this electro-magnet in being attracted breaks the circuit of the driving motor. During the period of break the armature of the motor and connected clockwork revolve with the momentum acquired, but the driving force being reperiod of contact of the springs G G^1 (fig. 30) decides the duration of the local current through the electro-magnet and hence determines the period of break of circuit. It was mentioned that the best action of the brake in a *weight* driven set, is obtained when the armature of the brake magnet is attracted at each revolution with a *varying* force. In the motor driven apparatus the rheostat R should be adjusted till the break circuit electro-magnet is attracted at each revolution, making this resistance a trifle less supplies the necessary variation of the period of break of circuit.

The armature A (fig. 75) of the electro-magnet E is similar to those employed in the receiver. It is provided with a spring S at the back, *i.e.* on the pivotted end, which in pressing against an adjustable screw C provides the necessary antagonistic force. A second spring S^1 fitted to the free end of the armature takes part in breaking the motor circuit. The play of the armature is regulated by the screw C^1 against which the spring S^1 works. Another long spring S^2 balanced on a central axes A^1 works against two adjustable screws C^2 and C^3. The screw C^2 is in the direct motor circuit and screw C^3 supplies the force of contact between the spring S^2 and screw C^2. The screws C^2 and C^3 should be so adjusted that the spring S can be lowered to the full extent to which the armature can be attracted and with the armature at rest a good contact should be ensured between S^2 and C^2. The connections of the motor are shown in fig. 75. S^3 is a snap switch which is employed to break the circuit of the motor M. R^1 is a resistance of 30 ohms. It will be noticed, in following the descent of the armature A that when the spring S^1 first touches S^2 the circuit of the battery is closed through R^1 for a very brief instant of time, and that subsequently the terminals of the motor are connected through this resistance, thus sparking at break of circuit at the contact C^2, is avoided and a path is opened to the back *e m f* of the motor, while it is revolving with its acquired momentum.

In the maintenance of the motor driven sets care should be taken to see :—

(*a*) That the armature revolves without friction against the magnets forming the field or else variations in speed will result.

(*b*) That the brushes are firmly placed on the commutator.

(*c*) That the bristles of the brushes are even and touch only one segment of the commutator at a time.

(*d*) That the commutator is clean and even ; fine emery should be used to obtain the desired result.

(*e*) That the axle of the armature is well oiled.

(*f*) That the driving current is not increased when from any cause speed varies. All other parts of the circuit should be examined carefully when a speed fault occurs.

225. For purposes of duplication of the received record, or for introducing a receiver into circuit in place of a faulty one, as also during short repairs to the driving gear on the receiving arm, the adoption of a switching method has been found useful. An ordinary two way six bar tumbler switch may be used for the purpose. The six leads to the five electro-magnets and the brake magnet of the receiver on the sending arm should be connected to the centre bars, the earth connection being as usual led direct to terminal 7 in the test box. On either side of these centre bars should be connected the segments of the first ring and the brake segments of the third ring, *viz.*, segment 6 to 10, ring I, and segments 7 and 8 ring III, to one side; and segments 1 to 5 ring I, and segments 2 and 3, ring III, to the other. Evidently with the switch turned to the one side the receiver is connected to the first arm and when turned to the other, to the second arm. If the duplication method is required for reception on the first arm segments 1 to 5 ring I, and segments 2 and 3 ring III, will have a double set of connecting wires, and both receivers can thus be joined parallel to produce a double record.

226. In testing for faults it is convenient to utilise the galvanometer which is supplied to all Baudot stations The galvanometer or detector is provided with two coils one of 100 ohms, and the other of 0·2 ohms. The 100 ohm coil should be used when high voltages are used in testing for insulation; and the 0·2 coil may be used in connection with one cell in tests for continuity. Testing with this galvanometer by the step by step method is desirable.

227. Care should be taken that the clamping screws on the back and front plate of the key-boards are tightly fixed. Loose screws will result in the batteries being cut off permanently or intermittently. When the back plate screw on the receiving arm is loose the relay will be cut off. It will be found that with the back plate removed good reception may be practicable. This is explained by the fact that though the direct path for the received current through the contact springs of the key-board is cut off, a path is still open through the leak. This occurs when the incoming impulses are strong and the relay is very sensitively adjusted. It must therefore, be noted that though a loose back plate screw may not cause a bad reception, care must be taken to have the screw tight so as to guard against a faulty reception when the received currents are weak.

228. The proper functioning of both the relay and electro-corrector may be verified locally at a corrected station by depressing the fifth key of the second key-board, when the electro-corrector should act at each revolution. This is due to the positive impulse from the fifth key operating the relay through the leak, till the negative from the first key of the first key-board returns the relay tongue to the rest contact; the tongue of the relay, being at the working stop when the brush of ring I is passing over the movable contact causes the electro-corrector to function. The above test also proves that the relay is adjusted without any negative bias.

229. Owing to a weak PL battery and consequent weak brake action the receivers may be occasionally running fast. It may sometimes occur that, due to a disconnection, only one of the two segments on ring III provides a path to the brake current, thus diminishing the duration and weakening the brake action. In all cases of weak brake action after verification of the battery voltage the above point should not be lost sight of.

230. It may occur after fitting up a set for the first time or after re-fitting, that the main batteries are reversed. This will be evidenced by a succession of P's when the key-boards are at rest, and when the letter T is transmitted, the letter G will be recorded, and *vice versa*.

231. In conclusion, a few hints for beginners on the key-board will be given.

It has been found that the most useful exercise for the learner at the Baudot key-board is the transmission of a series of T Gs. This exercise results in proper attention being paid to the cadence and a free use of all fingers. The word "Eye" forms an useful exercise for the third finger. After these two exercises the beginner may proceed to the transmission of small words and then small sentences. The following sentences, which are used on the Murray, are good for practice as they contain all the letters in the alphabet; the last is excellent practice for a beginner.

The quick brown fox jumps over the lazy dog.
Pack my trunk with five dozen liquor jugs
Kaufen sie jede woche vier gute bequeme pelze.

The beginner should whilst transmitting watch his local record and not his fingers.

DIAGRAM—CHAPTER X—*(concld.)*

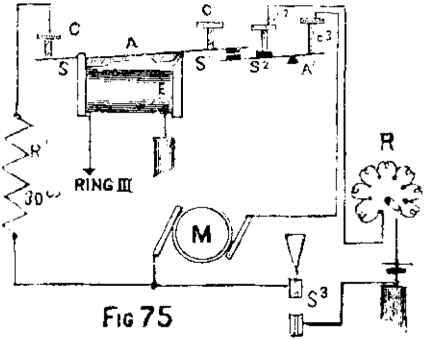


Fig 75